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Federal Regulation of Emerging Technologies and Its Implications for Transhumanist Applications of NBIC Technologies

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CLAREMONT MCKENNA COLLEGE

FEDERAL REGULATION OF EMERGING TECHNOLOGIES AND ITS IMPLICATIONS FOR
TRANSHUMANIST APPLICATIONS OF NBIC TECHNOLOGIES

SUBMITTED TO

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FOR

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CONTENTS

CHAPTER 1 – INTRODUCTION.....	I
The State of the Regulatory State.....	3
The Future, and Our Past.....	7
CHAPTER 2 – THE FDA.....	10
The Mother of Necessity: The Elixir Sulfanilamide Incident of 1937.....	11
The Price and Prize of Vigilance: The Thalidomide Crisis.....	13
The Experiences of a Century.....	18
CHAPTER 3 – THE FCC.....	22
Free Speech v. The Values of Anytown, USA.....	24
The High Water Mark of Obscenity Law: The Communications Decency Act.....	27
The Revolution Will Not Be Legislated: Contemporary Media Regulation.....	31
CHAPTER 4 – EMERGING TECHNOLOGIES AND THEIR TRANSHUMANIST IMPLICATIONS.....	37
The NBIC Paradigm and Its Importance.....	43
The Curious Harp of Man’s Body: Nanomedicine.....	46
Seeing Things Invisible: Pervasive Augmented Reality.....	51
By Our Epiphanies: Human Enhancement.....	57
CHAPTER 5 – REGULATING AN UNSEEN FUTURE.....	62
The Short Trudge from Adam to Atom.....	63
The Mark of a Good Action.....	68
BIBLIOGRAPHY.....	76

As for the future, your task is not to foresee it, but to enable it.
—ANTOINE DE SAINT-EXUPÉRY

You are by your epiphany a veritable “god from the machine.”
—MENANDER

CHAPTER 1 – INTRODUCTION

History shows us that technological innovation does not merely affect the application or applications for which they were intended. The direct outcomes of a given technological development typically do not even begin to tap into the vast range of latent possibilities; few if any in the 1940s and 1950s could have gazed upon the gargantuan but rudimentary adding machines that were vacuum-tube computers and envisioned the unprecedentedly transformative nature of their twenty-first-century counterparts, with their myriad applications and total ubiquity. The increasingly networked and digitized nature of modern life is but one of countless examples of how technological change necessarily has dramatic effects on human society. For instance, the Industrial Revolution clearly earned its name in the truest sense of the word: the development of the factory and assembly lines increased the rate and level of quality at which goods could be consistently made, but it also triggered a massive change in the way human societies were ordered, shifting millions of people across the world from rural areas—which, for millennia, most of humanity had called home—into cities. The automobile increased both the distance and the rate at which people could economically travel on their own, but it also came to define the nature of American society in the twentieth and twenty-first centuries through the inculcation of the “urban sprawl” paradigm—which, in another unintended consequence of technological advance, has become a substantial impediment to modern efforts to stave off catastrophic climate change caused by the use of fossil fuels. It is this aspect of technology—its ability to totally reshape our existence—that brings questions of government into the equation:

on what should government focus in order to attempt to anticipate such disruptions? If it is a matter that would benefit from some form of government action, how should it act—is it something that can be resolved through general education and the voluntary efforts of individuals in society, or is there a systemic issue involved which necessitates a protective response by government?

The capitalist system that has powered all these innovations is remarkable; history shows us that no other economic system has created nearly so much wealth, nor helped to lift so many people out of crushing poverty. Nonetheless, like many other manmade systems, capitalism is subject to its own shortcomings, excesses, and other ills. The necessity of some form of government action to protect its people from the dysfunctions of capitalism has been acknowledged and broadly supported for nearly a century now. Government regulation of pharmaceuticals and food products, to name but one example, has undeniably played a significant role in the sixty-six percent increase in the average life expectancy in the United States since 1900.¹ In spite of what some readings of American political history would have one believe, the American people have long understood and accepted the idea that there are matters of daily life, beyond the most basic machinations of the state, where some form of government action can be beneficial, or even necessary.² Such matters include basic workplace safety

¹ Andrew Noymer, “Life expectancy in the USA, 1900–98: men and women,” UC Berkeley, <http://demog.berkeley.edu/~andrew/1918/figure2.html> (accessed December 28, 2011); Kenneth D. Kochanek et al., “Preliminary Data for 2010,” U.S. Centers for Disease Control, *National Vital Statistics Reports* 60, no. 4 (January 12, 2012): 1–6, http://www.cdc.gov/nchs/data/nvsr/nvsr60/nvsr60_04.pdf (accessed September 18, 2012).

² “The legitimate object of government, is to do for a community of people, whatever they need to have done, but can not do, *at all*, or can not, *so well do*, for themselves—in their separate, and individual capacities.” Abraham Lincoln, “Fragment on Government,” in *Collected Works of Abraham Lincoln*, Vol. 2, ed. Roy P. Basler, Marion Dolores Pratt, and Lloyd A. Dunlap (Ann Arbor, Michigan: University of Michigan Digital Library Production

standards, quality assurance procedures, child labor laws, and protocols for controlling access to dangerous technologies. While it can be argued that such government action is incompatible with the Enlightenment-era political philosophies from which we derived our system of government, the reality is that the world has since become a considerably more complex place, and that modern governments have a legitimate interest in regulating the products of industry to some degree in order to ensure the safety and stability of society at a broad level. So far, this approach, while not without its own dysfunctions and problems, has been largely successful. But are modern governments and their regulatory agencies equipped to handle converging technologies that stand to change the nature of human existence itself? If so, can they adapt quickly enough to handle the possible emergence of these technologies within the next twenty to thirty years?

THE STATE OF THE REGULATORY STATE

While Congress has largely been able to keep up with broad technological innovation, a closer examination of federal statutes governing everything from the scope of the mandate of the Federal Communications Commission (FCC) to the way in which the Food and Drug Administration (FDA) classifies and regulates food and drug products reveals a system that is beginning to show its age. For example, the FCC's involvement in regulating indecent content on television is arguably an overextension of its mission, which at the present time is described by the FCC itself as:

Services, 2001), 220, <http://quod.lib.umich.edu/l/lincoln/lincoln2/1:261?rgn=div1;view=fulltext> (accessed November 2, 2012).

- Promoting competition, innovation, and investment in broadband services and facilities;
- Supporting the nation's economy by ensuring an appropriate competitive framework for the unfolding of the communications revolution;
- Encouraging the highest and best use of spectrum domestically and internationally;
- Revising media regulations so that new technologies flourish alongside diversity and localism;
- Providing leadership in strengthening the defense of the nation's communications infrastructure.³

Although those unfamiliar with the details could potentially construe the third item on this list as empowering the FCC to regulate broadcast content, it in fact refers merely to the optimum allocation of radio spectrum with regards to the volume (“highest”) and fidelity (“best”) of broadcasts. The particular phrasing of this list item appears nowhere in the 1978 Supreme Court case *FCC v. Pacifica Foundation*, in which the Court upheld the constitutionality of the FCC's ability, per 18 U.S.C. 1464, to regulate “any obscene, indecent, or profane language by means of radio communications.”⁴ The Court instead justified its decision on the grounds of “the uniquely pervasive presence that [broadcasting] occupies in the lives of our people”—not only was it, in the Court's view, “impossible completely to avoid those [broadcasts] that are patently offensive,” but it was also a medium “uniquely accessible to children.”⁵ In 1978, and arguably for the following two decades, this was undoubtedly true. However, this would change after the battle in the mid-1990s over obscenity and indecency on the Internet. At its heart was the Communications Decency Act of 1996 (hereinafter CDA), which briefly applied to the Internet

³ Federal Communications Commission, “What We Do,” <http://www.fcc.gov/what-we-do> (accessed November 29, 2011).

⁴ *FCC v. Pacifica Foundation*, 438 U.S. 726 (1978), <http://supreme.justia.com/cases/federal/us/438/726/case.html> (accessed October 26, 2012).

⁵ *Ibid.*, 727-728.

the same relatively broad restrictions on indecent and obscene materials that governed media over other forms of telecommunications.⁶ The Supreme Court, however, having previously ruled in *FCC v. Sable Communications of California* that “indecenty law and the First Amendment cannot be uniformly applied across the board to all communication media,” deemed the CDA’s schema of restrictions as overly broad and struck it down in 1997’s *Reno v. American Civil Liberties Union*.⁷

The massive growth of consumer access to the Internet in the mid- to late-1990s, combined with the regulatory void that came into being following the CDA’s demise and the subsequent proliferation of explicit content on the Internet, has arguably rendered obsolete the Court’s ubiquity-based reasoning in *Pacifica*. Indeed, this exact line of reasoning was used in a recent *amicus* brief filed by a coalition of influential public policy organizations, including the Cato Institute and the Electronic Frontier Foundation, in the Supreme Court’s rehearing of 2009’s *FCC v. Fox Television Stations*.⁸ In that decision, the Court held that the FCC’s indecency policy was “neither ‘arbitrary’ nor ‘capricious’ [as determined by the 2007 Second Circuit decision under review],” and remanded any potential constitutional considerations to the

⁶ “The CDA, as passed, extends the antiharassment, indecency, and antiobscenity restrictions currently placed on telephone calls to ‘telecommunications devices’ and ‘interactive computer services.’” Robert Cannon, “The Legislative History of Senator Exon’s Communications Decency Act: Regulating Barbarians on the Information Superhighway,” Washington Internet Project, <http://www.cybertelecom.org/cda/cannon2.htm> (accessed November 29, 2011).

⁷ *Ibid.*

⁸ Trevor Timm, “EFF Asks Supreme Court to End the FCC’s Indecency Regulations,” *Deeplinks* (blog), Electronic Frontier Foundation, <https://www.eff.org/deeplinks/2011/11/eff-asks-supreme-court-end-fcc-s-indecency-regulations> (accessed November 30, 2011); Brief of the Cato Institute et al. as Amici Curiae in Support of Respondents, *FCC v. Fox Television Stations, Inc.*, 567 U.S. ____ (2012), <https://www.eff.org/sites/default/files/FCC%20v.%20Fox%20amicus.pdf> (accessed November 30, 2011).

Court of Appeals.⁹ On further review, the Second Circuit reaffirmed its 2007 decision, but on different grounds—namely, that it was an “unconstitutionally vague” infringement of broadcasters’ First Amendment rights.¹⁰ The Supreme Court, in turn, chose to uphold the Second Circuit’s judgment to vacate the fines originally levied by the FCC, but on due process grounds rather than First Amendment considerations, so as to preserve the flexibility of both the FCC and the courts to adjust the policy to conform to public standards.¹¹ Interestingly, however, Justice Ginsburg criticized the Court’s *Pacifica* reasoning in her concurrence, calling it “wrong when it was issued” and therefore “bear[ing] reconsideration,” owing to “[t]ime, technological advances, and the Commission’s untenable rulings in the cases now before the Court.”¹² But while such issues are still of undoubted importance, and rightfully so, there is nevertheless cause for concern in these proceedings. The inability of the legislature and judiciary to shape any sort of cohesive, reasonable regulatory schema for the Internet and its ever-increasing range of applications, as well as legislators’ apparent inability or unwillingness to stay informed about new innovations, bodes ill for the future—for there is good reason to believe that many of the cutting-edge technologies being worked on in labs across the world today, such as the increasingly common use of nanotechnology across a broad range of industries and applications, could result in more human progress during the next few decades than in the past ten thousand years of civilization.

⁹ *FCC v. Fox Television Stations, Inc.*, 556 U. S. ____ (2009), <http://www.supremecourt.gov/opinions/08pdf/07-582.pdf> (accessed November 30, 2011).

¹⁰ *Fox Television Stations, Inc. v. F.C.C.*, 613 F.3d 317 (2d Cir. 2010), <http://www.leagle.com/xmlResult.aspx?xmlDoc=In%20FCO%2020100713084.xml> (accessed October 15, 2012).

¹¹ *FCC v. Fox Television Stations, Inc.*, 567 U. S. ____ (2012), <http://www.supremecourt.gov/opinions/12pdf/10-1293f3e5.pdf> (accessed October 12, 2012).

¹² *Ibid.*

THE FUTURE, AND OUR PAST

The rate of technological innovation, already astoundingly fast throughout the twentieth century and the first decade of the twenty-first, is accelerating to truly dizzying heights. And while the path of human innovation has not (yet) brought us such science-fiction staples as flying cars, teleportation devices, or permanent manned lunar outposts, there are nonetheless a considerable number of thinkers who believe that we are on the precipice of an utterly unprecedented explosion of technological innovation and development—an event that would completely rewrite the rules of human existence. Such an event is known as a *technological singularity*, or simply “the Singularity,” and is prominently advocated by individuals like futurist Ray Kurzweil and others belonging to the *transhumanist* movement, broadly defined as covering all “[p]hilosophies of life...that seek the continuation and acceleration of the evolution of intelligent life beyond its currently human form and human limitations by means of science and technology, guided by life-promoting values.”¹³ The technologies predicted to emerge from the Singularity sound as if they were drawn directly from science fiction: quantum computers, ubiquitous wireless networks and pervasive computing, human- or above-human-level artificial intelligences, wide-scale application of nanotechnology in areas such as manufacturing and

¹³ Max More, “Lextropicon: Neologisms of Extropy,” Extropy Institute, <http://www.extropy.org/neologo.htm> (accessed October 10, 2012). This formulation is regarded as “the first definition of transhumanism in its modern sense,” although the first use of the term itself well predates More’s; Aldous Huxley’s brother Julian appears to have coined it in his 1927 work *Religion Without Revelation*, calling it “man remaining man, but transcending himself, by realizing new possibilities of and for his human nature.” Nick Bostrom, “A History of Transhumanist Thought,” *Journal of Evolution and Technology* 14, no. 1 (April 2005): 7, <http://www.nickbostrom.com/papers/history.pdf> (accessed October 31, 2011).

medicine, and biotechnological implants that could endow the user with literally superhuman abilities.

Although the items in this diverse range of innovations may not seem to have much in common at first glance, they are in fact increasingly grouped together under the theoretical framework of *technological convergence*, on the basis of “material unity at the nanoscale and on technology integration from that scale”—that is to say, because “the building blocks of matter that are fundamental to all sciences originate at the nanoscale,” technology capable of operating at this level could achieve outcomes that would be prohibitive or even impossible on larger scales. This paradigm is mostly commonly referenced by the initialism *NBIC*, short for *Nanotechnology-Biotechnology-Information technology-Cognitive science*. The envisioned “synergistic combination” of these fields, which is only in its infancy today, could very well yield the most radical social, economic, and medical advances yet seen in human history.¹⁴ Under this model, technological developments in formerly discrete and disparate fields will begin to overlap, resulting in such cross-applications of their fruits as nanobiotechnology, which broadly refers to biocompatible nano-scale materials engineered for therapeutic or enhancement purposes. In this near future, nanomedicine could allow a person to live twice as long as today or longer while reversing the deleterious effects of aging, ubiquitous wireless networking and wearable technologies would make the pervasive fusion of digital and physical environments a fact of daily life, and the boundaries between man and machine could begin to blur to such a degree as to be

¹⁴ Mihail C. Roco and William Sims Bainbridge, eds., *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, prepared by the National Science Foundation in cooperation with the U.S. Department of Commerce (Arlington, VA, 2002), <http://www.nanowerk.com/nanotechnology/reports/reportpdf/report87.pdf> (accessed November 18, 2011).

indistinguishable. How will current regulatory regimes, still trying to grapple with the capabilities and applications of the modern Internet over thirty years after its birth, be able to offer meaningful policy proposals and feedback regarding this radical new paradigm?¹⁵ Are they even capable of keeping up with such rapid innovation, or are they forever doomed to try to follow in its wake?

I will endeavor to answer these questions over the course of the next two chapters by examining four notable cases of regulatory action which I believe to be representative of the evolution of federal regulation over the course of the twentieth century: the 1937 mass poisonings tied to elixir sulfanilamide, which led to the establishment of the FDA as we know it today; the FDA's response to the thalidomide-induced birth defects crisis of the late fifties and early sixties; the 1978 Supreme Court case *FCC v. Pacifica Foundation*, which established the FCC's power to regulate obscene content in broadcasting; and early and recent attempts to establish regulatory standards for the Internet in the realms of obscenity law, copyright enforcement, and network neutrality. Chapter four describes a few of the emerging technologies currently being researched and developed in laboratories across the world, as well as some of the key ethical, political, and socioeconomic implications of the potential commercialization of these technologies. Finally, in chapter five, I will return to the aforementioned questions in the context of historical precedents, and offer recommendations for the future.

¹⁵ By "the modern Internet," I refer to the word's current colloquial usage (i.e., the physical network and the services and content on it), in contrast to its progenitor, ARPANET. On August 6, 1991, Sir Tim Berners-Lee, a British researcher at CERN, simultaneously announced the creation of the World Wide Web to Usenet's *alt.hypertext* newsgroup and published the world's first website, info.cern.ch.

CHAPTER 2 – THE FOOD AND DRUG ADMINISTRATION

The FDA is, by its nature, one of the most visible and influential regulatory agencies in the United States. Its duties are so commonplace as to be taken for granted; very few bat an eye at the idea of a federal agency testing and approving the various food and drug products brought to the market every day. Over the course of its more than seventy-year history, it has been at the forefront of not just food and medical products, but also the government's responses to various public health incidents. However, this was not always the case—in fact, there were essentially no federal statutes regarding food quality until the late nineteenth century. Owing to political concerns, the first such laws had to be “enacted...under the guise of a complex system of taxation,” whereby the Commissioner of Internal Revenue—originally an independent office within the Treasury Department, but today the head of the Internal Revenue Service—was authorized to retain “an analytical chemist and a microscopist” to determine if certain food products “contain[ed] ingredients deleterious to the public health.”¹ A number of subsequent statutes enacted through the turn of the twentieth century built off this foundation to form an *ad hoc* regulatory system governing disparate classes of food products until the passage of the Pure Food and Drugs Act of 1906. The Act superseded this prior amalgamation, expanding the regulatory purview of the federal government—this time under the auspices of the U.S. Department of Agriculture (USDA) rather than Treasury—to prevent the adulteration of

¹ Peter Barton Hutt and Peter Barton Hutt II, “A History of Government Regulation of Adulteration and Misbranding of Food,” *Food, Drug, Cosmetic Law Journal* 39 (1984): 45, <http://heinonline.org.ccl.idm.oclc.org/HOL/Page?handle=hein.journals/foodlj39&collection=journals&id=10> (accessed November 28, 2011).

“substances” and “articles” generally, although in practice these categories were still mostly concerned with food products and additives.² A considerable amount of political and judicial wrangling accompanied the halting enforcement of the Act after its passage, but over the course of the following thirty years, the USDA was nevertheless able to begin establishing firm precedents for a broader scope of federal regulation in matters of public health and nutrition.³

THE MOTHER OF NECESSITY: THE ELIXIR SULFANILAMIDE INCIDENT OF 1937

Although the mechanisms for broad food and drug regulation were in place, their effectiveness was limited by the fact that they were only loosely linked under the aegis of the USDA. Indeed, the USDA itself had identified the “serious limitations” of this state of affairs as early as 1917, but it was not until 1933 that substantive legislative efforts to remedy the issue were initiated, most prominently with “a complete revision” of the Pure Food and Drugs Act of 1906.⁴ The revised legislation languished for four years after its introduction, apparently of little concern to the rest of Congress, before tragic circumstances forced the federal government’s hand. In 1937, the S.E. Massengill Company, a pharmaceutical firm in Tennessee, released a liquid preparation of the antibiotic compound sulfanilamide (the active ingredient in “sulfa drugs”) in response to market demands for a better-tasting version of the drug that could be more easily administered to children. After some testing, the company’s chief chemist had settled on a preparation that consisted of nearly three-quarters diethylene glycol—a toxic compound that

² Ibid., 49.

³ Ibid., 55-61.

⁴ Ibid., 61-62.

causes severe kidney and liver damage, and which is better known today for its wide use in automotive antifreeze.⁵

The product, sold under the name “elixir sulfanilamide,” was distributed across the country. Shortly thereafter, reports of unexpected deaths, apparently tied to the ingestion of elixir sulfanilamide, began to come in from Tulsa, Oklahoma, where considerable amounts of the drug had been delivered. The head of the Tulsa County Medical Society, looking for answers, contacted the American Medical Association (AMA) for information on the elixir’s ingredients; the AMA responded that they were unaware of, and had never approved, any such product. Subsequent correspondence between the AMA and the S.E. Massengill Company revealed that the company had failed to perform any kind of toxicity tests on their product before its release. The company sent out over a thousand telegrams to institutions across the country recalling the deadly elixir, but by the time the product was finally pulled off the market, one hundred five people had died in what has been characterized as “one of the most consequential mass poisonings of the 20th century.”⁶

The tragedy further galvanized extant public concern about the need for federal food and drug regulation, in part due to the fact that the federal government had only been able to compel the elixir sulfanilamide recall because the drug was technically in violation of the 1906 Act’s

⁵ Paul M. Wax, M.D., “Elixirs, Diluents, and the Passage of the 1938 Federal Food, Drug and Cosmetic Act,” *Annals of Internal Medicine* 122, No. 6 (March 15, 1995): 456, <http://search.ebscohost.com.ccl.idm.oclc.org/login.aspx?direct=true&db=aph&AN=9504032158&site=ehost-live&scope=site> (accessed October 18, 2012); Carol Ballentine, “Taste of Raspberries, Taste of Death: The 1937 Elixir Sulfanilamide Incident,” *FDA Consumer*, June 1981, <http://www.fda.gov/AboutFDA/WhatWeDo/History/ProductRegulation/SulfanilamideDisaster/default.htm> (accessed October 18, 2012). Per Ballantine, the Massengill preparation used diethylene glycol for two reasons: (1) the chief chemist found that sulfanilamide was soluble in it, unlike in the other solvents more commonly used in elixirs; and (2) diethylene glycol’s hepato- and nephrotoxicity had only recently been established in clinical studies, the results of which were not known to the company’s owner or chief chemist.

⁶ Wax, 456-457.

provisions against misbranding.⁷ The Federal Food, Drug, and Cosmetic Act of 1938 was passed and signed into law shortly thereafter. Not only did the Act dramatically broaden and strengthen the regulatory powers of the federal government with regards to standards-setting and enforcement, but it also formally unified these powers for the first time under the aegis of the Food and Drug Administration.⁸ It would not take long for the fruits of this new approach to become apparent when the United States and the world were gripped by a new public health crisis of an even greater magnitude.

THE PRICE AND PRIZE OF VIGILANCE: THE THALIDOMIDE CRISIS

By the end of the 1950s, the FDA had largely become the fixture of American political and economic life that it still is today. Although its unprecedented regulatory power over food and drug products was not entirely impervious to legal assault, the agency had already been the recipient of highly favorable rulings from the nation's high courts, and it soon became virtually impossible to challenge FDA enforcement on the basis of "the statutory authority of the agency to engage in the type of regulatory control it was pursuing."⁹ However, the specific jurisdictions

⁷ "...the only basis of authority under the 1906 Act for FDA intervention to remove the Elixir from the public market was that the preparation was not actually an 'elixir' (a title which only strictly applies to products utilizing an alcohol-based solvent) and that the product was therefore misbranded." David L. Stepp, "The History of FDA Regulation of Biotechnology in the Twentieth Century" (unpublished third-year paper, Harvard Law School, 1999), 8-9, http://leda.law.harvard.edu/leda/data/257/Stepp,_David_00.pdf (accessed October 18, 2012).

⁸ Stepp, 9-13; Hutt and Hutt II, 62. Although the powers associated with the modern FDA had been present in some form since the passage of the 1906 Act, the FDA did not exist under that name until 1930, when it was formed from the USDA's then-defunct Bureau of Chemistry. For a fuller accounting of the FDA's organizational locations through history, see "Location of FDA and its Predecessors in Federal Government," U.S. Food and Drug Administration, <http://www.fda.gov/AboutFDA/WhatWeDo/History/Overviews/LocationofFDAanditsPredecessorsinFederalGovernment/default.htm> (accessed on October 19, 2012).

⁹ Hutt and Hutt II, 62. "The Supreme Court rules in *U.S. v. Sullivan* [1948] that FDA jurisdiction extends to retail stores...In *Alberty Food Products Co. v. U.S.* [1950], a U.S. Court of Appeals rules that the directions for use on a

and mechanisms over which the modern FDA enjoys control were not yet fully implemented. For example, the FDA had only limited review authority over new drugs, because

[u]nder the Act, a manufacturer could introduce a product into the market if the manufacturer itself believed that the product was “generally recognized as safe”, leaving FDA to contest the manufacturer’s assessment. Even if manufacturers conceded that a product was a “new drug” and thereby required the filing of an NDA [new drug application], FDA did not possess the authority to force the manufacturer to delay marketing the product while FDA evaluated the NDA (beyond a 180 day statutory waiting period), but merely possessed authority to declare an NDA ineffective after its evaluation. This second problem was compounded by the overwhelming volume of NDAs submitted to FDA under the 1938 Act. When evaluating an NDA, FDA was formally limited under the 1938 Act to considering only the safety of the product, and not its therapeutic effectiveness. Once an NDA became effective for a given product, other manufacturers began production of similar versions of the product under the assumption that such generic, or “me-too”, drugs were also considered “generally recognized as safe” and thereby covered under the pioneer NDA.¹⁰

However, the FDA reviewers devised a clever means to violate the letter of law at that time with a unique justification of, perhaps, more faithfully hewing to its spirit:

While the authority granted to FDA under the 1938 Act was in actuality limited to assessment of only the safety of a “new drug”, FDA reviewers often considered the therapeutic efficacy of the drugs as well. FDA took the position that the concept of drug safety can be viewed as a risk-benefit calculus, and, therefore, some consideration of efficacy—the benefit in the calculus—is inherent in the determination of safety. As a result, the concept of FDA statutory review of efficacy was foreshadowed long in advance by administrative necessities.¹¹

drug label must include the drug’s purpose.” Jay L. Wattenberg, “A History of the FDA and Drug Regulation in the United States,” U.S. Food and Drug Administration, <http://www.fda.gov/downloads/Drugs/ResourcesForYou/Consumers/BuyingUsingMedicineSafely/UnderstandingOver-the-CounterMedicines/ucm093550.pdf> (accessed October 19, 2012).

¹⁰ Stepp, 11-12.

¹¹ Ibid.

This more comprehensive “safety” review would prove to be of great utility—possibly more than anyone could have predicted—as the fifties came to a close. In 1957, a new sedative called thalidomide came onto the German market. The manufacturer of the drug, Chemie Grünenthal, said that the drug had no discernible adverse effects on morning wakefulness (i.e. sleep inertia, or “grogginess”), and was both non-toxic and safe for use by pregnant women. Initially marketed as a sleeping aid, its popularity grew substantially after it was discovered that it was also an effective treatment for morning sickness.¹²

By 1960, thalidomide was being sold across the world, including the rest of Europe, South America, and Canada—but not the United States. That year, however, the FDA received an NDA for thalidomide from Richardson-Merrell, a pharmaceutical company in Cincinnati. The task of reviewing the application was assigned to pharmacologist Frances Oldham Kelsey, who had only been at the FDA for a month. Although this would be her first review assignment, Kelsey was hardly a novice—a graduate of McGill University with a doctorate from the University of Chicago, she had worked on a critical project during World War II to develop an alternative treatment for malaria after Japanese forces seized major sources of quinine in the Pacific theater. Although the war ended before a solution could be devised, Kelsey nevertheless came away from the experience with significant insights; in the process of testing possible cures, she observed notable differences in the abilities of pregnant and embryonic rabbits to metabolize administered drugs, as well as the transport, in pregnant rabbits, of some drugs from the mother’s bloodstream

¹² Linda Bren, “Frances Oldham Kelsey: FDA Medical Reviewer Leaves Her Mark on History,” *FDA Consumer*, March–April 2001, http://permanent.access.gpo.gov/lps1609/www.fda.gov/fdac/features/2001/201_kelsey.html (accessed on October 21, 2012).

into that of the fetus. Nearly twenty years later, Kelsey's wartime research experience would come to serve her well.¹³

As she reviewed the data from the thalidomide application, Kelsey became increasingly concerned about the drug's efficacy and safety. Further examination indicated an astonishing lack of empirical data on such critical factors as drug toxicity, drug metabolism, and controls on manufacturing quality, further heightening her skepticism. Her requests to Richardson-Merrell for more detailed information were met, but the data were of dubious quality—more anecdotal than empirical. As the days after the application's submission turned into weeks, and the weeks into months, Richardson-Merrell's representative started attempting to pressure Kelsey directly and indirectly. However, she remained steadfast in requesting additional data to either verify or dispute the drug's safety. Her cautious approach was soon vindicated. In December 1960, the *British Medical Journal* featured a letter from a physician who reported that he had observed some of his patients who had been taking thalidomide for extended periods were experiencing severe nerve pain. After reading the letter, Kelsey requested yet more information from the applying firm, reasoning that a drug with neuropathic effects could negatively affect fetal development. It was not long before her instincts were proven horrifically correct—doctors across Europe began to report unprecedented levels of birth defects, infant mortality, and miscarriages. Not until November 1961 was thalidomide determined to be the causative agent; on hearing the news, Chemie Grünenthal initiated a recall, as did the public health authorities of

¹³ Ibid.

many other nations where it had been prescribed. Unfortunately, it came too late for far too many—over 10,000 children in 46 countries had been delivered with serious birth defects.¹⁴

Richardson-Merrell's application for thalidomide approval in the United States was withdrawn in March 1962. Although some thalidomide tablets had gone out to American doctors on an "investigational basis," the drug was never officially approved for use in the United States, averting a major tragedy in the vein of what had occurred in Europe and much of the rest of the world. Out of an estimated 20,000 patients who had been given thalidomide, including some hundreds of pregnant women, only 17 children were born in the United States with deformities caused by thalidomide. The *Washington Post* ran a front-page story a few months later, in July, declaring Kelsey a "heroine" for her role in "prevent[ing] what could have been an appalling American tragedy." The following month, she received the President's Award for Distinguished Federal Civilian Service—the highest honorary award that can be given to civilians employed by the federal government—from President John F. Kennedy. In October of that year, Kennedy signed into law the Kefauver-Harris Amendment to the Federal Food, Drug, and Cosmetic Act of 1938, which instituted the modern requirement of drug manufacturers needing to demonstrate a drug's safety *and* efficacy in order to receive FDA approval. Shortly thereafter, Kelsey was put in charge of the FDA's new investigational unit; she has since been acknowledged as the mother of modern clinical science and modern pharmaceutical regulation in the United States. She would

¹⁴ Ibid.

remain at the FDA for forty-five years until her retirement in 2005 at the age of 90. Now 98, she lives in Maryland.¹⁵

THE EXPERIENCES OF A CENTURY

The first half of the twentieth century had seen what was, in relative terms, a veritable flood of legislation and jurisprudence designed to better equip the federal government—and the people of the United States—for a modern world that was becoming increasingly complex and, potentially, even more dangerous. But it was clear that more reform was needed, especially as scientific progress, and the rate of new product submissions, accelerated. The Supreme Court continued to rule in the FDA’s favor as far as industry challenges to its regulatory powers were concerned, which in many cases kept the FDA from having to deal with massive additional workloads caused by new legal gray areas.¹⁶ Still, the FDA could not avoid it all—after a series of high-profile regulatory failures at the National Institutes of Health regarding biologics (“any virus, therapeutic serum, toxin, antitoxin, vaccine, blood, blood component, or derivative...applicable to the prevention, treatment, or cure of diseases”), a frustrated Congress reassigned this responsibility to the FDA in the Consumer Safety Act of 1972.¹⁷

Just a few years later, Congress dramatically expanded the FDA’s purview over the regulation of medical devices, originally granted in the 1938 Act, with the Device Amendments of 1976; the Amendments were deliberately designed to be as broadly applicable to diagnostic and

¹⁵ Ibid.; Gardiner Harris, “The Public’s Quiet Savior from Harmful Medicines,” *New York Times*, September 13, 2010, <http://www.nytimes.com/2010/09/14/health/14kelsey.html> (accessed October 22, 2012).

¹⁶ Stepp, 18–19. See also *Weinberger v. Hynson, Westcott, and Dunning*, 412 U.S. 609 (1973), and *USV Pharmaceutical Corp. v. Weinberger*, 412 U.S. 655 (1973).

¹⁷ Stepp, 21, 24–25.

therapeutic devices as possible, and placed these devices under the same regulatory model as had been originally applied to drugs in the 1938 Act. By the end of the decade, the FDA bore the primary administrative responsibility for the regulation of drugs, biologics, medical devices, and food products.¹⁸ However, the advent of biotechnology in the early 1980s strained FDA resources, and the agency's ability to fit these radical new products into its existing regulatory structure, as it had elected to do.¹⁹ The FDA's review system, while thorough and effective, was beginning to fall behind the pace of innovation, heralding an unprecedented attitudinal shift toward the agency's work—whereas Congress had traditionally shown far more concern about the FDA's ability (or inability) to keep dangerous drugs off the market, it was now increasingly focusing on the possibility that the FDA was becoming a fatal barrier for new medical technologies.²⁰ A series of major reforms to streamline the FDA approval process and improve industry incentives began in 1984 with the Drug Price Competition and Patent Term Restoration Act (also known as the Hatch-Waxman Amendments), which codified the current drug patent system: an extended period of patent exclusivity followed by rapid market approval of generic equivalents after the original patent's expiration. The Prescription Drug User Fee Act of 1992 established a framework for sustainably expanding FDA resources to cope with the ever-increasing number of new product approvals by levying sizable application fees on companies submitting approvals.²¹ Finally, the FDA Modernization Act of 1997 codified the framework and policies of the 1992 Act, as well as dramatically reorganizing the FDA's system of biotechnology

¹⁸ Ibid., 32, 37, 42.

¹⁹ Ibid., 58-59.

²⁰ Richard A. Merrill, "The Architecture of Government Regulation of Medical Products," *Virginia Law Review* 82, no. 8 (November 1996): 1789-1790, <http://www.jstor.org/stable/1073689> (accessed October 23, 2011).

²¹ Ibid., 1792, 1794-1795.

regulation to increase efficiency and clarity; the 1997 Act was itself reaffirmed and reinforced by the Food and Drug Amendments Act of 2007.²²

Though altogether too many had to suffer and have their lives cut short for many of these accomplishments to come about, the FDA managed to keep the American people safe even in the face of increasingly rapid pharmaceutical innovation. In fact, between 1976 and 2005 (the most recent year for which data was available), only twenty-seven *new molecular entities* (NMEs; defined by the FDA as “structurally unique active ingredients that have never before been marketed”)—out of 751 NMEs approved by the FDA during that same timeframe—were recalled for safety reasons, yielding an “accuracy” metric of approximately 96.4%.²³ A recent analysis of fifteen drugs withdrawn by the FDA between 2001 and 2010 determined that only two of the seven NDAs containing sufficient information for a substantive judgment had “safety data...[that] suggested potential safety signals,” concluding that “withdrawals could not have been predicted for the majority of drugs removed from the market.”²⁴ The aforementioned FDA Modernization Act of 1997 has been hailed as a model for rapidly and effectively updating regulations for emerging medical technologies. Still, substantial challenges remain: the rate of product approval submissions has continued to accelerate, which could overwhelm even the augmented resources

²² Stepp, 99-100; “Food and Drug Administration Amendments Act (FDAAA) of 2007,” U.S. Food and Drug Administration, <http://www.fda.gov/RegulatoryInformation/Legislation/FederalFoodDrugandCosmeticAct/FDCAAct/SignificantAmendmentsstotheFDCAAct/FoodandDrugAdministrationAmendmentsActof2007/default.htm> (accessed October 22, 2012).

²³ U.S. Food and Drug Administration, *CDER 2005 Report to the Nation: Improving Public Health Through Human Drugs* (Rockville, Maryland: 2005), 42-43, <http://www.fda.gov/downloads/AboutFDA/CentersOffices/CDER/WhatWeDo/UCMo78935.pdf> (accessed October 22, 2012); John P. Swann, Ph.D., “Summary of NDA Approvals and Receipts, 1938 to the present,” U.S. Food and Drug Administration, <http://www.fda.gov/AboutFDA/WhatWeDo/History/ProductRegulation/SummaryofNDAApprovalsReceipts1938tothepresent/default.htm> (accessed October 22, 2012).

²⁴ Jaya Sai V. Daggumalli and Irwin G. Martin, “Are Pharmaceutical Market Withdrawals Preventable?: A Preliminary Analysis,” *Drug Information Journal* 46, no. 6 (November 2012): 694-700, doi:10.1177/0092861512458776 (accessed October 22, 2012).

of the FDA; the agency has been tasked with new counterterrorism duties since the September 11 attacks without a commensurate increase in funding; and finally, the FDA continues to face severe budget cuts in spite of a history of being chronically underfunded relative to its mandates—a condition that had only begun to be redressed with modest budget increases over the past five years.²⁵

²⁵ John Miller, “Beyond Biotechnology: FDA Regulation of Nanomedicine,” *Columbia Science and Technology Law Review* 4 (2002): 1-39, <http://www.lexisnexis.com.ccl.idm.oclc.org/lnacui2api/api/version1/getDocCui?lni=48TK-TTPo-00SW-40R4&csi=237723&hl=t&hv=t&hnsd=f&hns=t&hgn=t&oc=00240&perma=true> (accessed October 23, 2011); Andrew Zajac, “FDA budget draws cries of ‘not enough’,” *Los Angeles Times*, February 11, 2010, <http://articles.latimes.com/2010/feb/11/nation/la-na-fda-budget11-2010feb11> (accessed October 22, 2012).

CHAPTER 3—THE FEDERAL COMMUNICATIONS COMMISSION

The Federal Communications Commission (FCC) occupies a unique place in the American regulatory landscape. Perhaps uniquely among nations, the United States is known for its near-absolute commitment to free speech; numerous Supreme Court cases have established and reaffirmed the exceptionally high standards that must be met in order for government infringement on the people's right to speech to be considered acceptable. Notably, in contrast to much of the European Union, these standards do not include such items as hate speech or incitement to violence. However, the FCC has become a highly anomalous exception to this principle, given the censorship power with which it was first endowed—although the Commission was arguably not principally meant to exercise it. The Communications Act of 1934, which formally established the FCC, defined its primary mission as

regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges.¹

Strangely, however, the Act as passed contains two passages explicitly addressing the issue of obscenity. The first affirms that

the [Federal Communications] Commission...as public convenience, interest, or necessity requires, shall...[h]ave authority to suspend the

¹ *Communications Act of 1934*, Public Law 416, 73rd Cong. (June 19, 1934), § 1, *U.S. Statutes at Large* 48 (1933-1934): 1064, http://constitution.org/uslaw/sal/o48_statutes_at_large.pdf (accessed October 24, 2012), codified at *U.S. Code* 47 (1934), § 151, <http://heinonline.org.ccl.idm.oclc.org/HOL/Page?handle=hein.uscode/usci934001&collection=uscode&index=uscode/uscb&id=2133> (accessed October 25, 2012).

license of any operator for a period not exceeding two years upon proof sufficient to satisfy the Commission that the licensee...has transmitted...radio communications containing profane or obscene words or language.²

To confuse matters further, the second such section simultaneously reaffirms and rejects (if implicitly) the aforementioned in *two proximate sentences*:

Nothing in this chapter shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commission which shall interfere with the right of free speech by means of radio communication. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.³

Although obscenity and the First Amendment have a long and tangled legal history—which lends legitimacy and real depth to this *prima facie* absurdity—it is beyond the scope of this work to explore fully. However, it seems safe to say that changing cultural and technological standards and have rendered the aforementioned statutes—which are still on the books⁴—severely outdated, if not obsolescent. Indeed, the FCC’s own formulation of their mission statement makes no mention of enforcing obscenity law (or any such euphemistic alternative as, for example, *upholding community standards*).⁵ Still, the FCC was given the statutory authority to implement

² *Communications Act of 1934*, codified at *U.S. Code* 47 (1934), § 303.

³ *Ibid.*, § 326.

⁴ The latter sentence from the original version of 47 U.S.C. 326, as cited here, was repealed in a 1948 amendment and recodified at 18 U.S.C. 1464, where it remains today. 47 U.S.C 326 (2012), <http://uscodebeta.house.gov/view.xhtml?req=47+USC+326> (accessed October 25, 2012).

⁵ U.S. Federal Communications Commission, “What We Do,” <http://www.fcc.gov/what-we-do> (accessed Nov. 29, 2011).

these anti-obscenity directives, and had begun to notably enforce them as early as 1937.⁶ But the primary relevance of the FCC's powers in this regard, particularly as they apply to current media, originate in one of the more notable cases in the history of the Supreme Court.

FREE SPEECH V. THE VALUES OF ANYTOWN, USA

In 1978, the Supreme Court offered what was then, and is still today, a defining precedent for statutory enforcement of anti-obscenity laws. In *FCC v. Pacifica Foundation*, the Court heard the case of a local radio station that had aired “Filthy Words,” a recording of a modified version of comedian George Carlin’s infamous “Seven Dirty Words” monologue—which, appropriately enough, satirized the prohibition on the broadcast use of the eponymous words. A local listener was driving with his young son when the broadcast of the monologue came on, and filed a complaint with the FCC; the Commission upheld the father’s complaint, and while declining to levy a fine or other form of sanction against the station, informed its owners that it would keep the complaint “associated with the station’s license file, and, in the event subsequent complaints are received, the Commission will then decide whether it should utilize any of the available sanctions it has been granted by Congress.”⁷ The U.S. Court of Appeals’ Second Circuit reversed the judgment on appeal, essentially on First Amendment grounds (although through different underlying rationales). When *Pacifica* reached the Court, however, the justices

⁶ “1937: A mildly risqué radio skit known as the ‘Adam and Eve’ sketch, featuring Mae West as Eve, causes a public uproar and earns NBC a written reprimand from the FCC.” Lili Levi, “The FCC’s Regulation of Indecency,” *First Reports* 7, no. 1 (April 2008): 3, http://www.firstamendmentcenter.org/madison/wp-content/uploads/2011/03/FirstReport.Indecency.Levi_final_.pdf (accessed October 26, 2012).

⁷ *FCC v. Pacifica Foundation*, 438 U.S. 726 (1978), <http://supreme.justia.com/cases/federal/us/438/726/case.html> (accessed October 26, 2012).

overturned the circuit decision, finding that the “uniquely pervasive presence” of broadcast media—even “in the privacy of the home, where the individual’s right to be left alone [i.e., from offensive material] plainly outweighs the First Amendment rights of an intruder”—warranted the guiding hand of the FCC under the auspices of nuisance law, and the right of parents to shield their children from inappropriate or offensive material.⁸ The decision was handed down by Justice John P. Stevens, Justice William Rehnquist, and Chief Justice Warren E. Burger, with Justices Lewis F. Powell, Jr. and Harry Blackmun concurring.

Notably, however, in a move that would foreshadow future legislative and judicial clashes over obscenity law, Justices William J. Brennan, Jr. and Thurgood Marshall issued a scathing dissent comprehensively attacking the intellectual and jurisprudential grounds of the majority opinion as “completely antithetical to First Amendment values,” and borne of “an acute ethnocentric myopia.”⁹ Elaborating further, Brennan asserted that the majority’s rationale for the decision “[did] not support even the professedly moderate degree of governmental homogenization of radio communications – if, indeed, such homogenization can ever be moderate”; to find grounds for injury by offensive broadcast material in one’s own home on a device as easily deactivated as a radio (thus remedying the problem), Brennan reasoned, would be to establish an untenable standard for “intolerable invasion[s] of privacy,” and allow “a majority to silence dissidents simply as a matter of personal predilections.” Accusing the Court of “fail[ing] to accord proper weight to the interest of listeners who wish to hear broadcasts the

⁸ *Pacifica Foundation*, 438 U.S. 726 (1978), at 748-751.

⁹ *Ibid.*, 762, 775. See also Stewart’s dissent at 777-780, joined by Brennan, White, and Marshall, which focused more narrowly on what Stewart perceived as an inappropriate answering of a constitutional question that had not actually been raised within the scope of the original case.

FCC deems offensive,” he argued that “[n]o decision of this Court supports such a result” as the majority’s opinion in *Pacifica*; citing an earlier obscenity case, *Rowan v. Post Office Dept.*, he noted that the decision there—which upheld the right of households to opt out, in a legally binding fashion, of mailing lists which contained “lewd or offensive materials”—did not turn on any “governmental evaluation of the worth of the mail’s content,” while “the visage of the censor [was] all too clear” in *Pacifica*.¹⁰ Nevertheless, the *Pacifica* decision became the cornerstone of the FCC’s powers under 18 U.S.C. 1464, and gave the FCC much broader latitude to vigorously pursue and prosecute broadcasters who aired “offensive materials” in violation of that statute—a power it would use extensively, and which would thereafter have a strong influence on future debates over obscenity law. However, rather than setting a definitive course regarding enforcement of indecency statutes, the FCC instead wavered considerably over the following twenty-five years, somehow managing to obfuscate the apparently decisive standard the Court had afforded it in *Pacifica*; it was not until the turn of the twenty-first century that the FCC began to dramatically reassert itself in matters of regulating obscenity.¹¹ By that time, however, changing social norms and technological advances would soon subject the FCC’s radical escalation of indecency penalties—and, by extension, the *Pacifica* rationale—to severe scrutiny.

¹⁰ Ibid., 764-766.

¹¹ Sarah Herman, “The Battle for the Remote Control—Has the FCC Worn Out Its Welcome in America’s Living Room?”, *Washington University Journal of Law and Policy* 38 (2012): 360-367, <http://digitalcommons.law.wustl.edu/cgi/viewcontent.cgi?article=1022&context=wujlp> (accessed November 22, 2012).

THE HIGH WATER MARK OF OBSCENITY LAW: THE COMMUNICATIONS DECENCY ACT

As one would expect, the Internet had an extraordinary impact on not just the telecommunications industry and technology broadly speaking, but also on the proverbial “rules of the game” that governed telecommunications to that point. Although its capabilities and use cases in 1996 paled in comparison to those in existence today, it nevertheless represented a radical shift from the mediums that had preceded it. Even in its early years, when the tools needed to access the Internet remained rudimentary and its argot and essence were either impenetrable or totally unknown to the general public, it enabled users anywhere in the world to communicate in real-time or near-real-time. With the advent of websites like Amazon and Yahoo! in 1994, and eBay and Craigslist in 1995, the Internet was already taking its place amongst some of the most important innovations of human history because of its ability—like the automobile and the airplane—to metaphorically shrink the globe. But while it was being lauded for its ability to connect people around the world “to discuss almost any subject that interest[ed] them, from antique tools to zoology,” the Internet was never purely edificatory even from its inception; as a Cato Institute policy paper from the period dryly noted, “People, it seems, are also interested in sex.”¹²

¹² Solveig Bernstein, “Beyond the Communications Decency Act: Constitutional Lessons of the Internet,” Cato Policy Analysis No. 262, November 4, 1996, <http://www.cato.org/pubs/pas/pa-262.html> (accessed October 29, 2012). It did not take long for two of the Web’s most well-known phenomena to arise after its birth. The first spam message, advertising a fraudulent service to increase immigrants’ chances of “winning” in the federal Green Card Lottery program, was sent by a pair of lawyers, Laurence Canter and Martha Siegel, on April 13, 1994; the adult magazine *Playboy* launched its website in August of the same year (although it was by no means the first pornographic material on the Internet). Ray Everett-Church, “The Spam That Started It All,” *Wired*, April 13, 1999, <http://www.wired.com/politics/law/news/1999/04/19098> (accessed October 30, 2012); *Playboy Enterprises v. Universal Tel-a-Talk*, E.D. Pa. 1998 (Nov. 3, 1998), <http://www.paed.uscourts.gov/documents/opinions/98dtr01p.pdf> (accessed October 30, 2012).

From a regulatory standpoint, however, the Internet was arguably a puzzling beast—it could reach more people than even television broadcasts could, but it also enabled targeted, point-to-point communications more analogous to amateur radio; it was neither private nor public, but both. Still, legislators took comparatively little time to identify the burgeoning threat that explicit material on the Internet posed to the moral fiber of the nation, and in 1995, Senator James Exon (D-NE) introduced the Communications Decency Act of 1996 (hereinafter CDA) to combat the proliferation of—and the exposure of minors to—pornography on the Internet.¹³ Its primary aim was to amend section 223 of Title 47 of the U.S. Code, which is nominally concerned with “Obscene or harassing telephone calls in the District of Columbia or in interstate or foreign communications,” to impose up to a \$100,000 fine and a maximum of two years imprisonment on anyone who made, sent, displayed, or made available to

a person under 18 years of age, any comment, request, suggestion, proposal, image, or other communication that, in context, depicts or describes, in terms patently offensive as measured by contemporary community standards, sexual or excretory activities or organs, regardless of whether the user of such service placed the call or initiated the communication.¹⁴

Oddly, while this responsibility was originally meant to fall under the purview of the FCC, as one might expect, the CDA instead gave this enforcement responsibility over to the Department of Justice (DOJ).¹⁵ Ironically, however, the DOJ actually opposed the bill as written, making its

¹³ “On June 14, 1995, Sen. Exon read into the record a prayer written by the Senate Chaplain which decried the dangers of on-line pornography. 141 Cong. Rec. S8329 (daily ed. June 14, 1995). Sen. [Patrick] Leahy suggested that it was perhaps inappropriate for the Senate Chaplain to be interjecting himself into public policy debates. 141 Cong. Rec. S8331 (daily ed. June 14, 1995).” Robert Cannon, “The Legislative History of Senator Exon’s Communications Decency Act: Regulating Barbarians on the Information Superhighway,” Washington Internet Project, <http://www.cybertelecom.org/cda/cannon2.htm> (accessed November 29, 2011).

¹⁴ Ibid.

¹⁵ Ibid.

concerns about the CDA's constitutionality and efficacy known in a pair of letters to Senator Patrick Leahy (D-VT); Leahy, a leading CDA opponent, advocated instead a bill that ruled out additional federal regulation on obscene online materials pending a proposed DOJ study to determine whether or not the then-current obscenity statutes were sufficient.¹⁶ Using that hoary trope of modern political discourse, the football metaphor, Exon alleged that Leahy's proposal was merely a means to "delay a punt," rather than an attempt to "move aggressively forward"—particularly in "the thoughtful manner embodied in the Exon-[Dan] Coats [R-IN] proposal"—as was required of a team trying to maintain possession at the end of a game.¹⁷ Leahy, in response, countered that it was in fact "the Exon-Coats amendment [that] punts, because it punts to the FCC the task of finding ways to restrict minors' access to indecent communications so users can implement them and have a defense to criminal prosecution."¹⁸

Despite repeated warnings from both Leahy and then-Senator Joe Biden (D-DE) about the potential for "mountains of litigation over its constitutionality, dragging on for years and years," the CDA passed the Senate in an 86-14 vote shortly thereafter.¹⁹ Following an October conference to hammer out differences with the House of Representatives' version of the legislation and another vote in both houses, President Bill Clinton signed the CDA into law on February 8, 1996. As it turned out, Biden's warning was only half-right—it took just ten months for the promised legal battle over the CDA's constitutionality to reach the Supreme Court.²⁰ In

¹⁶ 141 Cong. Rec. S8340-44 (daily ed. June 14, 1995) (statement of Sen. Leahy, including letters of May 3 and June 14, 1995 from Kent Markus, Acting Assistant Attorney General, Department of Justice), <http://www.gpo.gov/fdsys/pkg/CREC-1995-06-14/pdf/CREC-1995-06-14-pt1-PgS8310-3.pdf> (accessed October 30, 2012).

¹⁷ *Ibid.*, S8339.

¹⁸ *Ibid.*, S8342.

¹⁹ *Ibid.*, S8345-47 (statement of Sen. Biden and roll call vote on amendment no. 1362).

²⁰ Brian Nelson, "Supreme Court to consider Internet indecency law," CNN, December 6, 1996, <http://www.cnn>

June of that year, the District Court of Eastern Pennsylvania convened, per the expedited judicial review provision of the CDA itself, to hear a constitutional challenge to the law from nearly fifty assorted organizations grouped together under the appellation of “American Civil Liberties Union [ACLU] Foundation, et al.”²¹ They subsequently found that the two key provisions of the CDA—§223(a), the “indecent transmission” provision, and §223(d), the “patently offensive display” provision—were “unconstitutional on their face,” and granted a preliminary injunction against the CDA’s enforcement.²² After the Supreme Court issued its writ of *certiorari* (check for definitive) for the case in December, also pursuant to the aforementioned judicial review provision, it heard the arguments for the case in March of the following year.

The Government, represented by then-Attorney General Janet Reno, had put forward a number of defenses in the District Court case that were reexamined by the Supreme Court: existing precedent (*Ginsburg v. New York*, *FCC v. Pacifica Foundation*, *Renton v. Playtime Theatres*, etc.) in the area of regulating the availability of obscene content; existing precedent regarding justifications for federal regulation of certain types of media, as in *Red Lion Broadcasting Co. v. FCC*, *Turner Broadcasting System, Inc. v. FCC*, and *Sable Communications of California v. FCC*; the CDA’s “patently offensive” provision, which reiterated and reaffirmed one of the three “prongs” of the Court’s obscenity test from *Miller v. California*; the assertion

.com/US/9612/06/internet.indecency/index.html (accessed October 31, 2012).

²¹ Telecommunications Act of 1996, S. 652, 104th Cong. (Jan. 3, 1996), § 561, <http://www.gpo.gov/fdsys/pkg/BILLS-104s652enr/pdf/BILLS-104s652enr.pdf> (accessed October 29, 2012).

²² American Civil Liberties Union v. Reno, 929 F. Supp. 824 (E.D. Pa. 1996), http://scholar.google.com/scholar_case?case=7999801392201013395&q=929+F.+Supp.+824&hl=en&as_sdt=40000002 (accessed October 31, 2012). It should be noted, however, that the District Court: (1) targeted specific subdivisions of the named provisions, which I have omitted in the running text for the sake of brevity, and (2) did not itself use the exact nomenclature for these provisions as quoted above, although its constructions were very similar—the quoted phrasings come from the Supreme Court’s later opinion on the case. See *ibid.*, 849, 852; *Reno v. American Civil Liberties Union*, 521 U.S. 844 (1997), 859.

that there did not exist a “less restrictive” alternative means by which the same policy end could be achieved, and therefore was as “narrowly tailored” as possible; and finally, that the federal government had a compelling interest to regulate online speech because the proliferation of obscene content on the Internet was driving down the rate of user adoption.²³ Unfortunately for the Government, the Court ruled almost every aspect of these defenses “singularly unpersuasive,” and struck down both of the contested provisions in a stunning 9-0 vote as unacceptable infringements on the First Amendment right to freedom of speech, effectively gutting the CDA.²⁴

THE REVOLUTION WILL NOT BE LEGISLATED: CONTEMPORARY MEDIA REGULATION

Interestingly, some of the Court’s findings in *Reno v. ACLU* as to the nature of the Internet and its various uses that were used not only to justify striking down the CDA, but also to applying strict scrutiny to attempts to regulate online speech, were turned back onto the Court in its more recent examination of *FCC v. Fox Television Stations, Inc.*; in that case, three broadcasts from Fox and ABC between 2002 and 2003 featured allegedly indecent content that went uncensored at the time of their showing.²⁵ The issue at hand revolved around the FCC’s reversal of its own long-standing policy regarding brief uses of otherwise unacceptably indecent language, better known as “fleeting expletives.” Whereas the FCC had generally not considered such incidents “actionably indecent” in the past, it now held in its so-called “Golden Globes

²³ *ACLU*, 521 U.S. 844 (1997), at 845-846.

²⁴ *Ibid.*, 847, 882.

²⁵ *FCC v. Fox Television Stations, Inc.*, 567 U. S. ____ (2012), 6, <http://www.supremecourt.gov/opinions/11pdf/10-1293f3e5.pdf> (accessed Oct. 12, 2012).

Order”—after one such incident at those awards involving U2’s lead singer, Bono—that “the mere fact that specific words or phrases are not sustained or repeated does not mandate a finding that material that is otherwise patently offensive to the broadcast medium is not indecent.”²⁶ The FCC then found the aforementioned Fox and ABC broadcasts in violation of this reversed policy, despite the fact that both broadcasts had occurred before the Golden Globes incident that gave rise to the FCC’s order. Both broadcasters filed suit against the agency, seeking judicial review of the policy on the grounds that they “did not have...sufficient notice of what [was] proscribed.”²⁷ After a series of appeals that went through the Second Circuit up to the Supreme Court, and back down to the Second Circuit only to return to the Supreme Court, the latter made a decisive ruling on the issue; finding the order objectionable “on fair notice grounds under the Due Process Clause,” it vacated the FCC’s advisory warning against Fox and the punitive fine it levied against ABC.

Notably, however, it also explicitly refused to “address the First Amendment implications of the Commission’s indecency policy,” which had been raised by a broad coalition of non-profit interest groups and think tanks, including the Electronic Frontier Foundation (EFF) and the Cato Institute, as *amici curiae* in support of Fox et al., and was later found unconstitutionally vague by the Second Circuit on both of the occasions it heard the case.²⁸ Asserting that *Pacifica*’s “factual underpinnings have withered in the 33 years since it was

²⁶ U.S. Federal Communications Commission, Complaints Against Various Broadcast Licensees Regarding Their Airing of the “Golden Globe Awards” Program, 19 FCC Rcd. 4795 (2004), 4800, http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-43A1.pdf (accessed November 1, 2012).

²⁷ *Fox Television Stations*, 567 U. S. ____ (2012), at 12.

²⁸ *Ibid.*, 17, 2.

decided,” the *amici* parties concluded that “[t]he state of media and technology today directly challenges *Pacifica*’s assumption that broadcast television is a unique medium that deserves only watered-down First Amendment protection.”²⁹ Their argument revolves around three major thrusts: (1) the development of new technologies, as well as the convergence of new and existing technologies, had altered media consumption paradigms to the point that they were unrecognizable from their 1978 predecessors, and thus *Pacifica*’s claim about broadcast television’s “uniquely pervasive presence” no longer applied; (2) these new technologies dramatically increased consumers’ ability to exert precise control over the kinds of content entering their homes, thus rendering obsolete *Pacifica*’s judgment of broadcast television as a medium “uniquely accessible to children”; and (3) that this new level of control over content constituted a less restrictive means for regulating speech at the level of individual households, at the discretion of the parents, which the Court had previously ruled trumps more sweeping efforts by government.³⁰ Although the Court gave some dismissive passing notice to these arguments, it clearly did not dwell on them extensively, deeming such a challenge as an unnecessary expansion of the case’s scope.³¹ Nevertheless, the brief offers a compelling case for a serious reexamination of the underlying basis and reasoning of *Pacifica*—as was suggested, intriguingly, by Justice Ruth Bader Ginsburg, in her characteristically terse concurrence:

²⁹ Brief of the Cato Institute et al. as Amici Curiae in Support of Respondents, *FCC v. Fox Television Stations, Inc.*, 567 U.S. ____ (2012), at 3, <https://www.eff.org/sites/default/files/FCC%20v.%20Fox%20amicus.pdf> (accessed Nov. 30, 2011).

³⁰ *Ibid.*, 6, 8-15, 19-24.

³¹ “These arguments [from *amici* brief for the respondent] need not be addressed here. In light of the Court’s holding that the Commission’s policy failed to provide fair notice it is unnecessary to reconsider *Pacifica* at this time.” *Fox Television Stations*, 567 U. S. ____ (2012), at 17.

In my view, the Court's decision in *FCC v. Pacifica Foundation*...was wrong when it [was] issued. Time, technological advances, and the Commission's untenable rulings in the cases now before the Court show why *Pacifica* bears reconsideration.³²

However, it remains to be seen if the Court will be able or willing to overturn such an established precedent, especially in the face of what is arguably a far more pressing issue: a new wave of legislation aimed at regulating the Internet, specifically in the realm of copyright infringement and enforcement.

As the *amici* brief from Cato et al. mentioned, new technological advances have given consumers more choices of media than ever before. But in the midst of its discussion of DVRs, Hulu, and Netflix, it—perhaps wisely—neglected another avenue of acquiring and viewing media: filesharing. The concept first gained mainstream visibility in 1999 with the establishment of the infamous peer-to-peer service Napster, but facing severe legal troubles from irate record labels by 2001, it was quickly succeeded by decentralized alternatives like Kazaa and LimeWire. These successors, in turn, gave way to the ubiquitous BitTorrent protocol in 2004; today, it is estimated that BitTorrent transfers comprise between 20% and 40% of global Internet traffic at any given time, and it is widely considered the most efficient means of downloading or uploading large amounts of data.³³ However, despite some successful attempts to commercialize the technology, it has become synonymous with the piracy of copyrighted materials, and is frequently demonized by entertainment trade associations such as the Motion Picture Association of America (MPAA) and the Recording Industry Association of America (RIAA), as well as Internet

³² *Ibid.*, 19.

³³ BitTorrent, Inc., “BitTorrent and µTorrent Software Surpass 150 Million User Milestone; Announce New Consumer Electronics Partnerships,” January 9, 2012, http://www.bittorrent.com/company/about/ces_2012_150m_users (accessed November 2, 2012).

service providers (ISPs), who allege that BitTorrent traffic can negatively affect network bandwidth and latency.³⁴ Secretive efforts by ISPs to combat this scourge had the unintentional effect, once they became known to the public, of reinvigorating the debate around the concept of *net neutrality*—or the concept that ISPs should “treat all content, sites, and platforms equally”³⁵—which these efforts violated.³⁶

Although the FCC officially established a basic actionable framework supporting net neutrality back in 2005, it was not officially codified until 2010, and the agency has been subject to alternating criticisms that it has imposed an unnecessary burden on ISPs, and that it did not go far enough, leaving it with weak and ineffective rules.³⁷ As wired and wireless broadband Internet technologies continue to evolve, so too will the debate over the provisions of net neutrality and their necessity. Additional flashpoints have risen and continue to rise over concerted efforts by rights-holders, including the MPAA and RIAA, to impose “copyright maximalism” superseding the provisions of the current regime—the Digital Millennium Copyright Act (DMCA)—in

³⁴ David Kravets, “Comcast Discloses Throttling Practices – BitTorrent Targeted,” *Threat Level* (blog), *Wired*, September 19, 2008, <http://www.wired.com/threatlevel/2008/09/comcast-discos> (accessed November 2, 2012).

³⁵ Tim Wu, “Network Neutrality FAQ,” http://www.timwu.org/network_neutrality.html (accessed November 2, 2012). Wu, a professor at Columbia Law School, is credited with coining the term “network neutrality,” and is one of the leading researchers and scholars in the field.

³⁶ Notably, Comcast’s filtering of peer-to-peer traffic, which the FCC had ruled was a violation of existing network neutrality rules (see Kravets), was finally ended after brokering a deal with BitTorrent, Inc. CEO and co-founder Ashwin Navin (CMC ’99) to invest in the BitTorrent protocol and in Comcast’s own infrastructure to better support BitTorrent traffic over Comcast’s network. Peter Burrows, “Comcast’s P2P Conversion: I’ll Believe It When I See Results,” *The Tech Beat* (blog), *BusinessWeek*, March 28, 2008, http://www.businessweek.com/the_thread/techbeat/archives/2008/03/congratulations.html (accessed November 2, 2012).

³⁷ U.S. Federal Communications Commission, “Open Internet,” <http://www.fcc.gov/topic/open-internet> (accessed November 2, 2012); Brendan Sasso, “House GOP: FCC ‘twists the facts’ in report to justify legislation,” *Hillicon Valley* (blog), *The Hill*, August 21, 2012, <http://thehill.com/blogs/hillicon-valley/technology/244647-house-gop-fcc-twists-the-facts-in-report-to-justify-regulation> (accessed November 2, 2012); Tim Wu, “The Art of ‘Kicking The Can’—Uncertainty Rules When It Comes to Net Neutrality,” *TechCrunch* (blog), December 23, 2010, <http://techcrunch.com/2010/12/23/net-neutrality-rules-uncertainty> (accessed November 2, 2012).

domestic legislation such as the Combating Online Infringement and Counterfeits Act (COICA), the Stop Online Piracy Act (SOPA) and the PROTECT IP Act (PIPA), the Cyber Intelligence Sharing and Protection Act (CISPA), and via so-called “policy laundering” through secretive international agreements like the Anti-Counterfeiting Trade Agreement (ACTA) and the Comprehensive Economic and Trade Agreement (CETA) between Canada and the European Union.³⁸ The attempted passage of these various pieces of legislation sparked massive public outcry and various forms of protest across the Internet, which has so far been successful in blocking them; however, it appears that the efforts of industry groups and legislators to enact such laws, which opponents claim will have a devastating chilling effect on the Internet both privately and commercially, have not yet come to a close.³⁹ Needless to say, the continuing legislative squabbles over the artificial preservation of the pre-digital business models of major media conglomerates at the expense of nearly twenty years of Internet innovation seem to bode ill for the near-future prospects of effective and rational regulation of the emerging technologies of today, which promise to have an impact greater than anything else yet seen.

³⁸ Harold Feld, “Op-ed: MPAA/RIAA lose big as US backs copyright ‘limitations’,” *Ars Technica* (blog), July 8, 2012, <http://arstechnica.com/tech-policy/2012/07/op-ed-eus-rejection-of-acta-subtly-changed-trade-law-landscape> (accessed November 2, 2012); Rashmi Rangnath, “The TPP and Policy Laundering,” *Policy Blog*, Public Knowledge, March, 20, 2012, <http://www.publicknowledge.org/blog/tpp-and-policy-laundering> (accessed November 2, 2012).

³⁹ Stephanie Condon, “SOPA, PIPA: What you need to know,” CBS News, January 18, 2012, http://www.cbsnews.com/8301-503544_162-57360665-503544/sopa-pipa-what-you-need-to-know (accessed November 2, 2012); Mike Masnick, “But of Course: Ridiculous ACTA Provisions Magically Appear in CETA,” *TechDirt* (blog), October 12, 2012, <http://www.techdirt.com/articles/20121011/01370920676/course-ridiculous-acta-provisions-magically-appear-ceta.shtml> (accessed November 2, 2012).

CHAPTER 4—EMERGING TECHNOLOGIES AND THEIR TRANSHUMANIST IMPLICATIONS

Although many people, if asked, would naturally agree, in a conceptual sense, with the notion that the human race has advanced immeasurably in the past one hundred or even one thousand years, they may not as often view our present technological capabilities in light of the full scope of the history of human civilization; neither do they always recognize the significance of new technologies, throughout history, in relation to those that came before it. Approximately ten thousand years ago, man discovered the basic principles of agriculture, and developed rudimentary tools to aid them, allowing our species to emerge from millions of years of mere subsistence through hunting and gathering. Agriculture naturally required more permanent settlements, a mode of existence that in turn lent itself to a broader range of more specialized activities than existed in a society of hunter-gatherers. The basic foundations of civilization developed from this arrangement, spurring the emergence of proto-civilizations roughly six thousand years ago; these, in turn, would give way some three thousand years later to some of the first great ancient societies in human history, most notably in Mesopotamia and, more broadly, the Levant. From the first primitive club of bone to the machine gun and the nuclear missile; from the horse to the train and the automobile, the trireme to the *Titanic* and the supertanker; from the Wright Flyer to the Concorde and the Space Shuttle; and from the smoke signal to the wireless telegraph and the Internet—these technologies have all come to fruition in the course of the last three millennia, with many of them emerging in just the last century alone.

In an attempt to better anticipate future possibilities, many descriptions of this accelerating pace of technological advance have been put forward; among the best-known in recent history was Intel co-founder Gordon Moore's eponymous 1965 law, which stated that the number of transistors on integrated circuits would double every year.¹ In 1975, after Moore revised his estimates to a doubling every two years, Intel executive David House suggested the formulation that is more commonly (but erroneously) attributed to Moore today: that such a rate implied a commensurate increase in computer performance every eighteen months. As it happens, what one might call "House's corollary" was not far off—since 1975, performance has doubled every twenty months.² By 1980, the "cost of calculation"—that is, the material costs incurred in completing a given set of mathematical operations (e.g., *instructions per second*, or the more modern FLOPS, short for *floating-point operations per second*)—had already decreased by a factor of one trillion from the turn of the twentieth century; by 2002, that reduction was on the order of a factor of 4.7 trillion.³ Compared to the very first microprocessor, the Intel 4004, released in 1971, Intel's current multi-core processors are three hundred fifty thousand times

¹ Intel Corporation, "Moore's Law: Raising the Bar," Moore's Law 40th Anniversary Press Kit, http://download.intel.com/museum/Moores_Law/Printed_Materials/Moores_Law_Backgrounder.pdf (accessed November 9, 2012).

² Michael Kanellos, "Moore's Law to roll on for another decade," CNET News, February 10, 2003, <http://news.cnet.com/2100-1001-984051.html> (accessed November 9, 2012). It should be noted that the adherence of technology to Moore's Law has grown somewhat more complicated with the move to multi-core processors, an innovation for which Moore's Law does not itself explicitly account; however, as of 2012, it is estimated that computing power of a typical laptop has "increased more than a thousand-fold" in the past twenty years, a rate roughly equivalent to House's corollary. Dr. Francis Wray, "A Brief Future of Computing," PlanetHPC, Edinburgh Parallel Computing Centre, http://www.planethpc.eu/index.php?option=com_content&view=article&id=66:a-brief-future-of-computing&catid=1:articles&Itemid=3 (accessed November 10, 2012).

³ Hans Moravec, *Mind Children: The Future of the Robot and Human Intelligence* (Cambridge, MA: Harvard University Press, 1988), 68, <http://books.google.com/books?id=56mb7XuSx3QC&pg=PA68#v=onepage&q&f=false> (accessed November 10, 2012); William D. Nordhaus, "The Progress of Computing," Yale University in cooperation with the National Bureau of Economic Research (NBER), March 4, 2002, http://nordhaus.econ.yale.edu/prog_030402_all.pdf (accessed November 11, 2012).

more powerful while using approximately five thousand times less power—all while undercutting the 4004's costs by a factor of fifty thousand.⁴ A Cray supercomputer from the same era cost approximately \$8 million to build, and took up an entire room; the now-commonplace iPhone is more than one hundred times faster and costs twelve thousand times less.⁵

In November 2000, the world's fastest supercomputer was ASCI White, which ran on more than eight thousand IBM POWER3 processors running at a clock speed of 375 MHz each; it was a thousand times more powerful than Deep Blue, the machine that famously bested World Chess Champion Gary Kasparov in 1997.⁶ Last year, IBM's "Question Answering system" Watson famously won a special match of *Jeopardy!* against the game's top two (human) players; it ran on three hundred and sixty POWER7 octa-core processors running at 3.5 GHz each. This hardware, along with major advances in machine learning, natural language processing, and parallel processing, made Watson capable of analyzing five hundred gigabytes of data in one second; not only that, but its impressive array of finely-tuned algorithms and sixteen terabytes of memory allowed it to rapidly parse and contextualize *Jeopardy!* clues, which often "involve analyzing subtle meaning, irony, riddles, and other complexities in which humans excel and

⁴ Patrick Darling, "Intel Celebrates 40 Years of Digital Revolution," Intel Corporation, November 15, 2011, http://newsroom.intel.com/community/intel_newsroom/blog/2011/11/15/intel-celebrates-40-years-of-digital-revolution (accessed November 11, 2012).

⁵ Andrew Hessel, Marc Goodman, and Steven Kotler, "Hacking the President's DNA," *The Atlantic*, November 2012, http://www.theatlantic.com/magazine/archive/2012/11/hacking-the-presidents-dna/309147/?single_page=true (accessed November 12, 2012).

⁶ Hans Meuer et al., "ASCI White: Lawrence Livermore National Laboratory," the TOP500 Project, <http://www.top500.org/featured/systems/asci-white-lawrence-livermore-national-laboratory> (accessed November 12, 2012); Bronis R. de Supinski, "The ASCI PSE Milepost: Run-Time Systems Performance Tests" (paper presented at the 2001 International Conference on Parallel and Distributed Processing Techniques and Applications, Las Vegas, June 25-28, 2001), <https://e-reports-ext.llnl.gov/pdf/245340.pdf> (accessed November 12, 2012); Leander Kahney, "IBM's Got a Big, Bad Computer," *Wired*, June 29, 2000, <http://www.wired.com/science/discoveries/news/2000/06/37285?currentPage=all> (accessed November 25, 2012).

computers do not,” with surprising accuracy.⁷ The increasing power and decreasing size of computing technologies has had other profound effects outside of direct computation: “soldiers with bionic limbs are returning to active duty, and autonomous cars are driving down our streets.”⁸ And this astounding progress has only recently seemed to begin skirting its upper limits, despite perennial prognostications to the contrary; top researchers at Intel confirmed in September that Moore’s Law would continue to hold true for the next ten years, even as concerns have mounted over manufacturing and size constraints imposed by the laws of physics.⁹

Although Moore originally never intended for his prediction to apply to other fields, its principle of exponential growth in computing technology has been extrapolated to predict the possible developments of the near future, on the basis that the massive increases in computing power predicted by Moore’s Law will indirectly drive the ever-accelerating rate of technological innovation. Futurists Vernor Vinge and Ray Kurzweil, both of whom have backgrounds in computer science, cite Moore’s Law as the primary justification for their predictions, some of which might strike the average person as outlandish.¹⁰ Vinge, for example, predicted in 1993 that

⁷ IBM, “DeepQA Project: FAQs,” <http://www.research.ibm.com/deepqa/faq.shtml#2> (accessed November 12, 2012); David Davidian, “What Runs IBM Watson and Why,” *Confronting Techno-deception* (blog), IBM, February 3, 2011, https://www-304.ibm.com/connections/blogs/davidian/entry/what_runs_watson_and_why16?lang=en_us (accessed November 12, 2012); John Rennie, “How IBM’s Watson Computer Excels at *Jeopardy!*,” *The Gleaming Retort* (blog), Public Library of Science, <http://blogs.plos.org/retort/2011/02/14/how-ibm’s-watson-computer-will-excel-at-jeopardy> (accessed November 12, 2012).

⁸ Hessel, Goodman, and Kotler, “Hacking the President’s DNA.”

⁹ Damon Poeter, “Intel Bets on Moore’s Law for Another Decade,” *PC Magazine*, September 12, 2012, <http://www.pcmag.com/article2/0,2817,2409635,00.asp> (accessed November 11, 2012). “That’s what it’s been like with Moore’s Law. We thought there were physical limits and we speak casually about going to 10 nanometres...We see no end in sight and we’ve had 10 years of visibility for the last 30 years.” Jeremy Geelan, “Moore’s Law: ‘We See No End in Sight,’ Says Intel’s Pat Gelsinger,” *SOA World Magazine*, May 1, 2008, <http://java.sys-con.com/node/557154> (accessed November 11, 2012).

¹⁰ The skeptical reader might find it instructive to look to the past and extrapolating Moore’s Law forward to the present, as Intel itself did in 2011 for the 4004’s fortieth anniversary: if the cost of space travel had declined at the same rate as the cost of transistors since 1971, “the Apollo 11 mission, which cost about \$355 million in 1969, would

the accelerating improvements in computer hardware would lead to “the creation of greater than human intelligence...during the next thirty years.”¹¹ Kurzweil, meanwhile, estimated in his famous 2001 essay, “The Law of Accelerating Returns,” that computing power would increase at such a rate that by 2023 it would be possible to buy a computer with “one Human Brain capability,” equivalent in his model to twenty quadrillion calculations per second, for just \$1,000.¹² He later revised this estimate slightly upward, stating that he believed “a computer [would] reach human levels...by the end of the 2020s.”¹³ Kurzweil also charted the exponential growth of a host of other technologically relevant factors, including, among others: the time between a technology’s introduction and its mass adoption among the public; the cost per base pair of DNA sequencing; the amount of storage per dollar in both random access memory (RAM) as well as magnetic media; the cumulative bandwidth of the Internet backbone; and the total

cost about as much as a latte [today]”; alternatively, if Intel’s current multi-core processors were fabricated using the same technology that made the 4004, they “would be the size of a conference room” 23 ft by 10 ft (or 230 ft³), instead of their actual size of 37.5 mm by 37.5 mm (or approximately 2.18 in³). Intel Corporation, “40yrs of Intel microprocessor innovation: Following Moore’s Law the whole way,” http://download.intel.com/newsroom/kits/40thanniversary/pdfs/Intel_40th_infographic_sm.pdf (accessed November 11, 2012); Intel Corporation, “Intel Core i7-3632QM Processor (6M Cache, up to 3.20 GHz) rPGA,” under “Package Size” in “Package Specifications,” http://ark.intel.com/products/71458/Intel-Core-i7-3632QM-Processor-6M-Cache-up-to-3_20-GHz-rPGA (accessed November 11, 2012).

¹¹ So as to avoid “relative-time ambiguity,” he specified that he would “be surprised if this event occurs before 2005 or after 2030.” Vernor Vinge, “The Coming Technological Singularity” (paper presented at the VISION-21 Symposium, Westlake, OH, March 30-31, 1993), <http://accelerating.org/articles/comingtechsingularity.html> (accessed November 11, 2012).

¹² Ray Kurzweil, “The Law of Accelerating Returns,” under “The Law of Accelerating Returns Applied to the Growth of Computation,” March, 7, 2001, <http://www.kurzweilai.net/the-law-of-accelerating-returns> (accessed November 11, 2012). Cf. 22.81 billion instructions per second for the Intel Core i7-3770K, the fastest available desktop processor (at time of writing) in Intel’s current chipset line—fully six orders of magnitude below Kurzweil’s estimated requirement. (He appears to use “calculations per second” as a stand-in for the more formal benchmark of “instructions per second.”) Anand Lal Shimpi and Ryan Smith, “The Intel Ivy Bridge (Core i7 3770K) Review,” *AnandTech* (blog), April 23, 2012, <http://www.anandtech.com/show/5771/the-intel-ivy-bridge-core-i7-3770k-review/6> (accessed November 11, 2012).

¹³ Ray Kurzweil, “Kurzweil responds: Don’t underestimate the Singularity,” October 20, 2011, <http://www.kurzweilai.net/kurzweil-responds-dont-underestimate-the-singularity> (accessed November 11, 2012).

number of hosts on the Internet.¹⁴ He further suggests that the reason such figures and extrapolations can seem whimsical or unfounded to the layman is due to the fundamental nature by which we tend to view the past relative to the present—and, by extension, extrapolate data from the present into the future:

Most long range forecasts of technical feasibility in future time periods dramatically underestimate the power of future technology because they are based on what I call the “intuitive linear” view of technological progress rather than the “historical exponential view.” To express this another way, it is not the case that we will experience a hundred years of progress in the twenty-first century; rather we will witness on the order of twenty thousand years of progress (at *today’s* rate of progress, that is)...

When people think of a future period, they intuitively assume that the current rate of progress will continue for future periods...[because] even though the rate of progress in the very recent past (e.g., this past year) is far greater than it was ten years ago (let alone a hundred or a thousand years ago), our memories are nonetheless dominated by our very recent experience...

But a serious assessment of the history of technology shows that technological change is exponential. In exponential growth, we find that a key measurement such as computational power is multiplied by a constant factor for each unit of time (e.g., doubling every year) rather than just being added to incrementally. Exponential growth is a feature of any evolutionary process, of which technology is a primary example...

I emphasize this point because it is the most important failure that would-be prognosticators make in considering future trends. Most technology forecasts ignore altogether this “historical exponential view” of technological progress. That is why people tend to overestimate what can be achieved in the short term (because we tend to leave out necessary details), but underestimate what can be achieved in the long term (because the exponential growth is ignored).¹⁵

As outlandish as the promises of some of the following technologies might seem at first glance, they rest firmly within the realm of science, not science fiction. While a considerable number of

¹⁴ Kurzweil, “The Law of Accelerating Returns.”

¹⁵ Ibid.

people may be intuitively skeptical of the claims of technologies lying just beyond the metaphorical horizon—perhaps inoculated, as many were, by the unmet promises of the “techno-utopianism” of the “golden age of American futurism” envisioned during the Fifties and Sixties by such science fiction staples as “The Jetsons” (or, in later generations, by the dystopian environs of cyberpunk, as in William Gibson’s *Neuromancer* and Ridley Scott’s *Blade Runner*)¹⁶—the foregoing suggests that the selected technologies discussed in this chapter are not only technically possible, but commercially plausible in the next few decades. Indeed, it is no exaggeration to assert “that since the beginning of this century, rapidly accelerating technology has shown a distinct tendency to turn the impossible into the everyday in no time at all.”¹⁷ Although the socioeconomic and political effects of emerging technologies often confound the predictions of earlier eras, it seems that the technological trends of the past thirty years will broadly—and, indeed, logically—inform the developments of the next thirty.

THE NBIC PARADIGM AND ITS IMPORTANCE

As was noted in the first chapter of this paper, the NBIC (*Nanotechnology-Biotechnology-Information technology-Cognitive science*) paradigm is the overarching model under which the emerging technologies of today are classified. These four fields are fundamentally linked by the concept of “material unity at the nanoscale”—that is, the fact that “the building blocks of matter that are fundamental to all sciences originate at the nanoscale”—

¹⁶ Matt Novak, “50 Years of the Jetsons: Why the Show Still Matters,” *Paleofuture* (blog), *Smithsonian*, September 12, 2012, <http://blogs.smithsonianmag.com/paleofuture/2012/09/50-years-of-the-jetsons-why-the-show-still-matters> (accessed November 11, 2012).

¹⁷ Hessel, Goodman, and Kotler, “Hacking the President’s DNA.”

and the emerging technologies of today seek to achieve heretofore unseen outcomes via “technological integration from that scale.” However, one would be remiss in assuming that the fruits of NBIC technologies derive *solely* from the ability to manipulate matter at its smallest levels; rather, the NBIC paradigm also encompasses a sea change in the manner in which individual scientific disciplines are viewed in relation to one another, advocating as it does the “synergistic combination” of these fields in new ways to generate new ideas and innovations.¹⁸ Examples of these “converging” sciences include a variety of relatively new areas of study, including:

- *Bioinformatics*, “the study of information processes in biotic [i.e., biological] systems.” Applying principles from information technology to biology (and vice versa), research in this field includes genetic algorithms, “semi-independent parallel processing,” self-organizing computational paradigms, and a host of other “biologically-inspired computational ideas.”¹⁹
- *Computational neuroscience*, the study of “the properties characterizing and the principles governing neurons and networks of neurons...draw[ing] on both neurobiological data and computational ideas to investigate how neural networks can produce complex effects such as stereo vision, learning, and auditory location of sound-emitting objects.” Importantly, the *computational* aspect is meant to refer to “its descriptive connotation, which here betokens the deep-seated conviction that what is being modeled by a computer is itself a kind of computer,” despite its dissimilarities to the computer with which we are all more familiar. Particularly relevant to the scope of this paper is one subset of computational neuroscience, called *neural net modeling*, which

¹⁸ Mihail C. Roco and William Sims Bainbridge, eds., *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, prepared by the National Science Foundation in cooperation with the U.S. Department of Commerce (Arlington, VA, 2002), <http://www.nanowerk.com/nanotechnology/reports/reportpdf/report87.pdf> (accessed November 18, 2011).

¹⁹ Paulien Hogeweg, “The Roots of Bioinformatics in Theoretical Biology,” *PLoS Computational Biology* 7, no. 3 (March 2011): 1–5, <http://www.ploscompbiol.org/article/info%3Adoi%2F10.1371%2Fjournal.pcbi.1002021> (accessed November 12, 2012).

applies principles from neuroscience to information technology to attempt to create *artificial neural networks*.²⁰

- *Nanobiotechnology*, the “applications of nanotechnology techniques for the development and improvement of biotechnological processes and products,” including but not limited to the use of nanoscale machines for unprecedentedly accurate and sensitive diagnoses, precision drug administration, and “tissue engineering and regeneration.” Eventually, nanoscale machines could be employed “to perform medical procedures in patients” or act as “artificial alternative[s] to functional biological organs.”²¹

These are but a few of the scientific fields that are already giving rise to the earliest forms and applications of emerging technologies like nanotechnology. A more detailed review of these converging fields, and the emerging technologies for which they are responsible, is well beyond the scope of this paper; what follows, therefore, is an examination of selected emerging technologies, each belonging to one or more of the NBIC fields, in order to give an indication of how radically these technologies are poised to advance and reshape our global society, and the inevitable attendant challenges they will present in so doing.

²⁰ Patricia Smith Churchland and Terrence J. Sejnowski, *The Computational Brain*, rev. ed. (1992; repr., Cambridge, MA: MIT Press, 1996): 6-7, http://search.ebscohost.com.ccl.idm.oclc.org/login.aspx?direct=true&db=nlebk&AN=1809&site=ehost-live&scope=site&ebv=1&ppid=pp_6 (accessed November 12, 2012). Artificial neural networks can take two basic forms: the *connectionist* approach makes use of many individual analogues of biological neurons—typically in the form of purpose-built microchips—and connects them all together in much the same manner as neurons in the human brain, in order to study and harness the network’s emergent properties and processes; the *computationalist* theory, on the other hand, views the human brain as more analogous to an incredibly sophisticated computer, and tends to focus more on algorithmic and symbolic-processor models. Note that these two theories are not, strictly speaking, mutually exclusive; it is possible to hold that computationalist behavior is, in fact, an emergent property of a connectionist neural network. James Garson, “Connectionism,” *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, December 7, 2010, <http://plato.stanford.edu/archives/win2010/entries/connectionism> (accessed November 12, 2012); Steven Horst, “The Computational Theory of Mind,” *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, March 1, 2011, <http://plato.stanford.edu/archives/spr2011/entries/computational-mind> (accessed November 12, 2012).

²¹ Ehud Gazit, “Introduction: Nanobiotechnology and Bionanotechnology,” in *Plenty of Room for Biology at the Bottom: An Introduction to Nanobiotechnology* (London: Imperial College Press, 2007): 1, <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10188762> (accessed November 12, 2012).

While nanotechnology has been widely feted, perhaps to a skepticism-inducing degree, as a panacea for many of the ills that plague us—technological or otherwise—it is also difficult to understate its potential. Nanoscale manipulation of matter could unlock heretofore impossible or economically prohibitive materials and manufacturing techniques. One such example is the oft-discussed carbon nanotube, which has the greatest tensile strength of any known material; it is typically referred to in the context of advancing human spaceflight via the construction of a space elevator (which would obviate the need for resource-intensive rocket launches), because carbon nanotubes are the only material strong and light enough to plausibly allow a structure stretching up to geostationary orbit, an altitude of over twenty thousand miles, to support its own immense weight. But nanoscale manipulation of matter has implications even greater than the construction of gargantuan structures like the space elevator—“the unity of matter at the nanoscale” effectively “eras[es] the distinction between the organic and the inorganic,” because the nanoscale is essentially the atomic scale.²² At the atomic level, materials have fundamentally different properties than they do in their aggregated, macroscopic form, including properties that are literally impossible at macroscopic levels. What’s more, our intuitive understanding of how our current medical technology works in a broad sense breaks down almost completely at the nanoscale, because “when the focus is on atoms being rearranged, it makes no sense to

²² José López, “Bridging the Gaps: Science Fiction in Nanotechnology,” *International Journal for Philosophy of Chemistry* 10, no. 2 (2004): 129-152. <http://www.hyle.org/journal/issues/10-2/lopez.htm> (accessed November 13, 2012).

distinguish between chemical and physical forces.”²³ Although modern pharmaceuticals have effectively worked on a molecular scale for decades, scientists are only now beginning to develop an intricate understanding of the complex molecular and cellular processes underlying all the biological, chemical, and physical activities of the human body. Indeed, they continue to learn more on a regular basis: for example, scientists discovered just last year that intracellular motor proteins called *kinesins*—which are responsible, among other things, for transporting nutrients from other parts of the cell to the nucleus²⁴—were capable of moving both forwards *and* backwards along cellular microtubules; previously, it was thought that kinesins were only capable of forward motion.²⁵ But increased knowledge of cellular and molecular processes, and the ability to manipulate matter at the nanoscale, has already begun to enable new forms of medical treatment far more sophisticated than anything currently on the market.

Scientists have been experimenting with nanoscale materials for the better part of a decade now, and while the potential applications they have devised are still fairly primitive relative to what is technically possible, they nonetheless represent major steps forward in current medical knowledge and techniques. *Nanoparticles* are, as their name suggests, nanoscale particles of a variety of shapes, sizes, and configurations; scientists have achieved promising results in experiments making use of different types of nanoparticles to deliver drugs,

²³ John Miller, “Beyond Biotechnology: FDA Regulation of Nanomedicine,” *Columbia Science and Technology Law Review* 4 (2002/2003): 5, <http://www.lexisnexis.com.ccl.idm.oclc.org/lncuizapi/api/version1/getDocCui?lni=48TK-TTPo-00SW-40R4&csi=237723&hl=t&hv=t&hnsd=f&hns=t&hgn=t&oc=00240&perma=true> (accessed October 23, 2011).

²⁴ Harukata Miki, Yasushi Okada, and Nobutaka Hirokawa, “Analysis of the kinesin superfamily: insights into structure and function,” *Trends in Cell Biology* 15, no. 9 (September 2005): 467-476, doi:10.1016/j.tcb.2005.07.006 (accessed November 13, 2012).

²⁵ Adina Gerson-Gurwitz et al., “Directionality of individual kinesin-5 Cin8 motors is modulated by loop 8, ionic strength and microtubule geometry,” *European Molecular Biology Organization Journal* 30 (2011): 4942-4954, doi:10.1038/emboj.2011.403 (accessed November 13, 2012).

radiological markers, or other biocompatible materials to a specified site, including highly precise delivery of chemotherapy drugs to cancerous cells only, which, in leaving the surrounding healthy tissue unharmed, would dramatically reduce the side-effect profile of standard cancer treatments.²⁶ Another approach uses nanoparticles not for their ability to deliver drugs, but rather for their inherent physical properties and characteristics—gold nanoparticles can destroy cancerous tissue when excited with near infrared light, and similar work has been done with hafnium oxide nanoparticles activated by X-rays.²⁷ Nanoparticles have also been used, to great effect, to improve the resolution of magnetic resonance imaging (MRI) scans by using biodegradable nanoparticles to convey contrast markers across the blood-brain barrier, which is typically impermeable to much of the biological and chemical material present in the circulatory system.²⁸ Although these technologies are still in their infancy, relatively speaking, they are vital for establishing the basic principles for the more advanced applications that have already been considered.

One such application is the use of *nanobots*, or nanoscale robots, to perform a variety of therapeutic functions within the human body. The role in which they are most commonly envisioned is that of a sort of cellular maintenance system. In this model, nanobots equipped with

²⁶ Barbara Haley, M.D., and Eugene Frenkel, M.D., “Nanoparticles for drug delivery in cancer treatment,” *Urologic Oncology: Seminars and Original Investigations* 26 (2008): 57-64, doi:10.1016/j.urolonc.2007.03.015 (accessed November 13, 2012); James H. Adair et al., “Nanoparticulate Alternatives for Drug Delivery,” *ACS Nano* 4, no. 9 (2010): 4967-4970, doi:10.1021/nn102324e (accessed November 13, 2012).

²⁷ Weibo Cai et al., “Applications of gold nanoparticles in cancer nanotechnology,” *Nanotechnology, Science and Applications* 1 (2008): 17-32, doi:10.2147/NSA.S3788 (accessed November 13, 2012); Nanobiotix S.A., “Phase I IDMC confirms good safety of NBTXR3 in the first group of patients with advanced STS,” press release, November 13, 2012, <http://www.nanobiotix.com/news/release/phase-i-idmc-confirms-good-safety-of-nbtxr3-in-the-first-group-of-patients-with-advanced-sts> (accessed November 13, 2012).

²⁸ Robert M. Koffie et al., “Nanoparticles enhance brain delivery of blood-brain barrier-impermeable probes for *in vivo* optical and magnetic resonance imaging,” *Proceedings of the National Academy of Sciences* 108, no. 46 (November 15, 2011): 18837-18842, doi:10.1073/pnas.111405108 (accessed November 16, 2011).

an array of nanoscale sensors and manipulators travel through the body via the circulatory system, making use of the microfluidic forces of the flow of blood itself (and/or some form of independent locomotion, such as artificial flagella or even nanoscale propellers), actively carrying out repair and protection functions as it does so.²⁹ These roving nanobots could attack and destroy pathogens, cancerous cells, and other harmful agents throughout the body before they reach levels detectable by current diagnostic tests, or even before a major immune response would typically be triggered; they could also perform *ad hoc* cell and tissue repair, reversing damage before it becomes systemic. In fact, such on-demand repair could even extend the average lifespan—recent experimental findings suggest that the effects of aging may be due to an increasing number of cells near their replication limit that linger in the body, releasing “inflammatory proteins and other cellular pollutants,” rather than dying and being broken down by the immune system or flushed out of the body; the accumulation of these waste products within the body, in turn, can interfere with or trigger dysfunctions in the operations of healthy cells, and these dysfunctions manifest themselves on a macroscopic level as aging, as well as “heart disease and cancer and other conditions that become more likely with age.”³⁰ Highly-sophisticated, autonomous nanobots could, in theory, target these byproducts of cellular senescence and either break them down or flush them from the body, effectively “halting” the aging process by preventing the gradual damage from cellular senescence from building up to

²⁹ Roco and Bainbridge, 256; Nathan A. Weir, Dannelle P. Sierra, and James F. Jones, *A Review of Research in the Field of Nanorobotics*, prepared by the Sandia National Laboratories in cooperation with the U.S. Department of Energy (Arlington, VA, 2005), 11-12, doi:10.2172/875622 (accessed November 5, 2012); Ambarish Ghosh and Peer Fischer, “Controlled Propulsion of Artificial Magnetic Nanostructured Propellers,” *ACS Nano Letters* 9, no. 6 (2009): 2243-2245, doi:10.102/nl900186w (accessed November 13, 2012).

³⁰ Brandon Keim, “Cell-Aging Hack Opens Longevity Research Frontier,” *Wired*, November 2, 2011, <http://www.wired.com/wiredscience/2011/11/cellular-senescence> (accessed November 10, 2012).

harmful levels. Leading gerontologist Aubrey de Grey refers to these techniques more colorfully in his 2007 book, *Ending Aging*, as “Upgrading the Biological Incinerators” and “Putting the Zombies to Rest”; he combines these phenomena with five others under one unifying framework for age-related dysfunction to be addressed by his “Strategies for Engineered Negligible Senescence” (SENS).³¹ Although careful to note the provisional nature of research in the field thus far, and the long road yet to travel before we have the knowledge and technology—including the aforementioned nanobots—to reverse the aging process, de Grey ultimately concludes that it is within the realm of possibility that individuals alive today could very well live to be “one thousand years of age and to avoid age-related health problems even at that age.”³²

Needless to say, the effects of such a breakthrough on human civilization would be truly profound—all our laws, our institutions, our intuitions, our behaviors and norms, are predicated *by necessity* on the average human lifespan. When that lifespan jumps from roughly eighty years to several hundred or more—and with better overall health over that latter period, to boot—with the help of the technologies we have devised ourselves, does the label of “human” continue to apply, unabated? Can we—or should we—really elide such a massive leap in our species’ history, of “man remaining man, but transcending himself by realizing new possibilities of and for his human nature,” by refusing to acknowledge it in our self-identification?³³ At what point would we then recognize that, though our origins are still unmistakably human, we have at the same time

³¹ Aubrey de Grey, Ph.D., with Michael Rae, *Ending Aging: The Rejuvenation Breakthroughs That Could Reverse Human Aging in Our Lifetime* (New York: St. Martin’s Press, 2007), 101, 200, x.

³² *Ibid.*, 277, 325.

³³ Julian Huxley, *Religion Without Revelation* (New York: Harper & Brothers, 1927), quoted in Nick Bostrom, “A History of Transhumanist Thought,” *Journal of Evolution and Technology* 14, no. 1 (April 2005): 7, <http://www.nickbostrom.com/papers/history.pdf> (accessed October 31, 2011).

advanced beyond some of the most fundamental limitations of our origins?³⁴ If such an event does not qualify us as *transhuman*, what will?

SEEING THINGS INVISIBLE: PERVASIVE AUGMENTED REALITY

As our scientific knowledge has advanced through the centuries, we have become increasingly comfortable with—or, at the very least, resigned to—the fact that many of the important phenomena of the world around us are beyond our sight. The human eye, as incredibly intricate as it is, can only absorb visible light, which comprises a relatively narrow band of the full electromagnetic (EM) spectrum. Although we make use of all the other types of electromagnetic radiation on the spectrum—radio, microwave, infrared, ultraviolet, X-ray, and gamma ray—the unaided human eye will never be capable of perceiving them directly. Over time, of course, technology has aided us in bringing some of these forms of radiation into use by “translating” them into a form we can perceive in the visible part of the spectrum (e.g., infrared night-vision goggles, thermal imaging, and diagnostic radiology). As one would expect, our sense perceptions influence the way we think and act; if, for example, humans were naturally able to see into the infrared range and could therefore see thermal images, the concept of night might not be as readily associated in our culture with the concepts of fear and evil as it is today, since we would not be without what is arguably our most important sense of all. Likewise, in any well-populated area in the developed world, you will very likely find yourself in the midst of an enormous,

³⁴ Cf. “posthuman”: “possible future beings whose basic capacities so radically exceed those of present humans as to be no longer unambiguously human by our current standards.” Humanity+, “What is a posthuman?” The Transhumanist FAQ 3.0, http://humanityplus.org/philosophy/transhumanist-faq/#answer_20 (accessed November 14, 2012).

invisible tempest of radio waves and other EM radiation; it goes without saying that our technology would have probably developed along very different lines if we were in some way naturally capable of perceiving these waves, if for no other reason than to avoid massive sensory overload.

But these radio waves and other forms of EM radiation we are “saturating” the air with have a purpose—radio waves, at various frequencies along the spectrum, carry everything from AM and FM audio, to television broadcasts, to Wi-Fi and cellular voice and data. Within this unseen cacophony is a truly enormous amount of data: cellular data usage alone reached a total of more than 1.1 trillion megabytes (MB) for the period between July 2011 and June 2012.³⁵ Since the beginning of the twenty-first century, the potent combination of increasing Internet connectivity, network bandwidth and speed, and falling prices for digital storage media have driven a new data-aggregation paradigm that has in recent years been given the appellation “Big Data.” If anything, “Big Data” is actually something of an understatement, considering that an estimated 2.5 exabytes (EB) of data are created every day—“so much that 90% of the data in the world today has been created in the last two years alone.”³⁶ Immense amounts of this data are now being associated with offline activities, events, items, and more—one could consider it digital

³⁵ CTIA – The Wireless Association, “Total Wireless Data Traffic” in “2012 Semi-Annual Wireless Industry Survey,” June 30, 2012, http://files.ctia.org/pdf/CTIA_Survey_MY_2012_Graphics-_final.pdf (accessed November 14, 2012). To give some sense of scale to this enormous figure, 1.1 trillion MB is equivalent to 1.1 EB—approximately one-tenth of the estimated information content of all human knowledge (12 EB), or about twelve times the estimated information content of the so-called “Deep Web” (91,000 terabytes [TB]), which refers to all the data on the Internet which is not indexed by search engines because of access restrictions or architectural incompatibilities. Wolfram Alpha LLC, “1.1 trillion megabytes,” Wolfram | Alpha query, <http://www.wolframalpha.com/input/?i=1.1%20trillion%20megabytes> (accessed November 14, 2012); UC Berkeley Library, “Invisible or Deep Web: What it is, how to find it, and its inherent ambiguity,” <http://www.lib.berkeley.edu/TeachingLib/Guides/Internet/InvisibleWeb.html> (accessed November 14, 2012).

³⁶ IBM, “Bringing big data to the enterprise,” <http://www-01.ibm.com/software/data/bigdata> (accessed November 14, 2012).

metadata for the physical world. The line between the digital and the physical, once well-defined and seemingly immutable, has already begun to blur; in fact, that distinction is set to all but disappear.

Augmented reality (AR) is the use of digital artifacts or data to augment an individual's view of the physical world. The general concept is hardly a new one—the basic concept of an augmented reality display was envisioned as early as 1901, and arguably came into being for the first time some fifty years later, in the form of the heads-up display (HUD).³⁷ They quickly became ubiquitous in both military and civilian aircraft, and were even installed in some production cars; they were also frequently used by robotic or cyborg characters in science fiction, perhaps most prominently in such genre staples as the *Terminator* and *RoboCop* series, among others. HUDs continue to find new applications in a variety of fields, including an innovative use in GPS-enabled “smart snowplows” clearing truck routes to remote ports and oil facilities in Alaska in the near-constant darkness of its treacherous winter season.³⁸ Most notably, however, augmented reality has begun to come into its own as a consumer offering in mobile apps alongside the proliferation of smartphones equipped with high-resolution cameras, powerful processors, and “always-on” high-speed data connections. In June 2009, mobile AR

³⁷ Joel Johnson, “‘The Master Key’: L. Frank Baum envisions augmented reality glasses in 1901,” *Mote & Beam* (blog), September 10, 2012, <http://moteandbeam.net/the-master-key-l-frank-baum-envisions-ar-glasses-in-1901> (accessed November 14, 2012). “The prototype [HUD] first flew on 30th April 1958...the Buccaneer HUD was manufactured and further developed continuing up to a Mark III version with a total of 375 systems made; it was given a ‘fit and forget’ title by the Royal Navy and it was still in service nearly 25 years later. BAE Systems thus has a claim to the world’s first Head Up Display in operational service.” Rochester Avionic Archives, “Buccaneer HUD PDU,” BAE Systems Rochester, http://www.rochesteravionicarchives.co.uk/View_Object?ObjectId=1097 (accessed November 14, 2012).

³⁸ Elaine Pittman, “Smart Snowplows Keep the Highway to Valdez, Alaska, Clear,” *Government Technology*, March 15, 2012, <http://www.govtech.com/e-government/Smart-Snowplows-Keep-the-Highway-to-Valdez-Alaska-Clear.html> (accessed November 23, 2012).

made a breakthrough on the smartphone platform in the form of Layar, “the world’s first mobile augmented reality browser,” which could integrate with other web services like Twitter and Google Local Search to overlay information onto a live view of the world through the phone’s camera.³⁹ In August of that year, local search and review site Yelp became the first company to bring AR integration to the iPhone, and in December, Internet behemoth Google released its Google Goggles app, which used sophisticated algorithms to match elements of user-photographed objects against similar elements in Google’s enormous image search database, and subsequently extract that information as text input for a Google search; later, the app even gained the ability to solve photographed Sudoku puzzles.⁴⁰ While these apps have done much to acclimate the public to the idea of augmented reality as a useful tool in everyday life, they are still limited by the constraints of their platform, and have arguably failed to tap into consumer behavioral patterns. However, recent advances in microelectromechanical systems (MEMS) might very well change that.

Babak Parviz was, until very recently, the McMorrow Innovation Associate Professor at the University of Washington (UW), specializing in MEMS, microtechnology, and nanotechnology; he also served as the Associate Director of UW’s Micro-scale Life Sciences

³⁹ Robin Wauters, “Layar’s Augmented Reality Browser: Literally More Than Meets the Eye,” *TechCrunch* (blog), June 21, 2009, <http://techcrunch.com/2009/06/21/layars-augmented-reality-browser-literally-more-than-meets-the-eye> (accessed November 14, 2012); SPRXmobile, “Layar Reality Browser, Version 2.0,” July 9, 2009, <http://web.archive.org/web/20090709061420/http://layar.com> (accessed November 14, 2012). The original group behind Layar, cited above, appears to be defunct; the Layar app itself has since been remade into a platform for AR integration with print media.

⁴⁰ Brian X. Chen, “Yelp Sneaks Augmented Reality Into iPhone App,” *Gadget Lab* (blog), *Wired*, August 27, 2009, <http://www.wired.com/gadgetlab/2009/08/yelp-ar> (accessed November 14, 2012); JR Raphael, “A Hands-On Tour: Google Goggles Visual Search,” under “Tech Events,” *PCWorld*, December 7, 2009, http://www.pcworld.com/article/183933/Google_Goggles_Visual_Search_A_HandsOn_Tour.html?page=0 (accessed November 14, 2012). “Google Goggles: Snap a photo of what you see to find more information about products, landmarks or famous paintings, and even solve Sudoku puzzles.” Google, Inc., “Google Search,” under “Description,” iTunes Preview, <https://itunes.apple.com/us/app/google-search/id284815942> (accessed November 14, 2012).

Center, involved in work on neural implants and “smart” bandages.⁴¹ After nine years at UW, he was hired by Google to head up its Project Glass, an effort by its secretive “experimental unit,” Google X, to launch an affordable consumer-oriented AR head-mounted display (HMD) resembling a pair of eyeglasses by 2014. The device is meant to be paired with a smartphone over a low-power, short-range radio connection to send and receive data, and is equipped with a wide array of sensors, a camera, and sufficient storage and processing power to stream live video from the device.⁴² Although Project Glass is a laudably ambitious and impressive effort, Parviz’s prior experimental work is arguably even more so: he rose to prominence for his work on what has been dubbed a “bionic contact lens.”⁴³ The lenses themselves are not substantially different from the ones sold to consumers by the millions every year; where the bionic lens truly differs from its commercial counterparts is its intricate network of embedded circuitry. Using an innovative solution-based self-assembly process, precisely-machined micrometer-scale components are fitted by shape into tiny slots on the surface of the contact lens itself, then set with a low-temperature treatment, and finally sealed into the lens with a top layer of polymer.⁴⁴

Parviz and his team were able to build a sort of proof-of-concept AR display into one of the lenses they made, creating a lens with an embedded LED that was wirelessly powered via

⁴¹ David Teicher, “Through Google Glasses, Babak Parviz Envisions Brighter Future,” *Advertising Age*, July 9, 2012, <http://adage.com/article/creativity-50/creativity-50-2012-babak-parviz-google-glasses/235765> (accessed November 14, 2012).

⁴² Steven Levy, “Google Glass Team: ‘Wearable Computing Will Be the Norm’,” *Gadget Lab* (blog), *Wired*, June 29, 2012, <http://www.wired.com/gadgetlab/2012/06/clear-glass-leaders-google-wearable-computing-breakthrough-explain-it-all-for-you/all> (accessed November 14, 2012).

⁴³ Joab Jackson, “‘Bionic’ Contact Lens May Create Tiny Personal Displays,” *National Geographic Daily News*, January 29, 2008, <http://news.nationalgeographic.com/news/2008/01/080129-bionic-eye.html> (accessed November 14, 2012).

⁴⁴ Babak A. Parviz, “Augmented Reality in a Contact Lens,” *IEEE Spectrum*, September 2009, <http://spectrum.ieee.org/biomedical/bionics/augmented-reality-in-a-contact-lens/o> (accessed October 4, 2011).

radio frequency (RF); they later expanded on the original design by using Fresnel lensing to shift the focal point of the LED's light more directly onto the retina, improving perceived image resolution, as well as demonstrating the feasibility of powering the lenses' electronics through embedded micro solar cells.⁴⁵ The lenses have also been demonstrated to have other applications, including as a diagnostic device, since certain biological markers are present in lacrimal fluid at levels correlating to their concentration in the blood.⁴⁶ In the future, more advanced versions of this technology could seamlessly analyze the view before you and display relevant data on-the-fly, filtered through what it has algorithmically “learned” about your habits and preferences in your daily life—if, for example, you were to pass a row of newly-opened storefronts on your daily jog, your bionic lenses could cross-reference your recent purchase history at online retailers with the inventories of the storefronts, and display relevant information about offerings you might like or an ongoing sale, or it could even “tag” the building with a digital artifact only visible to you as a

⁴⁵ Andrew R. Lingley et al., “A single-pixel wireless contact lens display,” *Journal of Micromechanics and Microengineering* 8 (2011): 1-8, doi:10.1088/0960-1317/21/12/125014 (accessed November 24, 2011); Ramin Mirjalili and Babak A. Parviz, “Microlight-emitting diode with integrated Fresnel zone plate for contact lens embedded display,” *Journal of Micro/Nanolithography, MEMS, and MOEMS* 11, no. 3 (July-September 2012): 1-7, doi:10.1117/1.JMM.11.3.033010 (accessed November 5, 2012); Andrew R. Lingley et al., “A contact lens with integrated micro solar cells,” *Microsystem Technologies* 18 (2012): 453-458, doi:10.1007/s00542-011-1417-5 (accessed November 3, 2012).

⁴⁶ Huanfen Yao et al., “A Dual Microscale Glucose Sensor on a Contact Lens, Tested in Conditions Mimicking the Eye,” paper presented at the Institute of Electrical and Electronics Engineers’ annual International Conference on Micro Electro Mechanical Systems, Cancun, Mexico, January 23-27, 2011, <http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5734353> (accessed November 6, 2011); Nicole Thomas, Ilkka Lähdesmäki, and Babak A. Parviz, “A contact lens with an integrated lactate sensor,” *Sensors and Actuators B: Chemical* 162 (2012): 128-134, doi:10.1016/j.snb.2011.12.049 (accessed November 3, 2012); Yu-Te Liao et al., “A 3- μ W CMOS Glucose Sensor for Wireless Contact-Lens Tear Glucose Monitoring,” *IEEE Journal of Solid-State Circuits* 47, no. 1 (January 2012): 335-344, doi:10.1109/JSSC.2011.2170633 (accessed November 3, 2012); Nicole Thomas, Ilkka Lähdesmäki, and Babak A. Parviz, “An electro-enzymatic flexible molecular lactate sensor,” paper presented at the Institute of Electrical and Electronics Engineers’ annual International Conference on Nano/Micro Engineered and Molecular Systems, Kyoto, Japan, March 5-8, 2012, doi:10.1109/NEMS.2012.6196802 (accessed November 5, 2012).

reminder to stop in at some point in the future.⁴⁷ Bionic lenses could interface with the electronics in our cars to display speedometer and navigation data, as well as tracking the speed and maneuvers of other vehicles on the road, including in our “blind spots”; paired with facial recognition and data from social networks and the public Web, these lenses could also act as a sort of intelligent address book that would help facilitate routine social interactions with acquaintances or networking connections. It should be noted that Parviz himself admits the technology has a long way to go to reach even basic commercially-viable display capabilities, let alone any of the foregoing futuristic scenarios.⁴⁸ However, once that threshold is crossed, the possibilities are endless.

BY OUR EPIPHANIES: HUMAN ENHANCEMENT

Although the technologies described in the previous two sections would constitute major advances in and of their own right, neither has quite the same potential to challenge our ideas of what it means to be human as the constellation of devices that fall under the broad category of human enhancement technologies (HET). And while HETs technically include nanomedical applications as described earlier in the chapter, there is a wealth of other compelling research

⁴⁷ Unlikely as it may seem, examples of “tagging” real-world locations with such digital artifacts already exist, predominantly through a number of smartphone apps. Recent examples include “Street Tag,” which allows the user to engage in augmented-reality graffiti; “Ingress,” a social science fiction game from Google; and “Minecraft Reality,” which allows players of the hit indie game *Minecraft* to “place” their in-game creations into real-world locations, and view other creations placed in the surrounding area. Channel 4, “Street Tag,” iTunes Preview, <https://itunes.apple.com/us/app/street-tag/id451000359> (accessed November 25, 2012); Nathan Ingraham, “Google’s ‘Ingress’ augmented reality game puts Android users into a battle against worldwide mind control,” *The Verge* (blog), November 15, 2012, <http://www.theverge.com/2012/11/15/3649668/google-ingress-augmented-reality-game-beta> (accessed November 20, 2012); Owen Hill, “Announcing Minecraft Reality for iOS,” Mojang AB, November 25, 2012, <http://mojang.com/2012/11/announcing-minecraft-reality-for-ios> (accessed November 25, 2012).

⁴⁸ Parviz, Babak A. “TEDxUChicago 2012 - Babak Parviz - Nanotechnology,” TEDxTalks, YouTube video, 16:47, <http://www.youtube.com/watch?v=NqDqhzJzQrU> (accessed November 3, 2012).

efforts occurring in other fields falling under the HET label. Chief among these are biotechnological implants and bionic limbs and organs; progress in the latter category is developing rapidly relative to the other technologies mentioned here, if only because researchers have had greater success in designing wholly external electromechanical prosthetic limbs or regenerating organs from some “cellular scaffolding” and the patient’s own cells, rather than attempting to meld man and machine in any real, intrinsic fashion. Still, as nanoscale manufacturing grows more advanced, enabling the mass production of lightweight and extremely durable nanocomposites, as well as muscle-fiber biomimicry, we might see prosthetic devices transition from being mere substitutes for missing body parts into true bionic devices whose capabilities utterly surpass their biological progenitors. Such technology is already in active development, and is beginning to emerge even now—in November 2012, researchers at the University of Texas announced that they had succeeded in manufacturing carbon nanotube muscle fibers eighty-five times more powerful than those found in mammals.⁴⁹ Such breakthroughs raise a host of ethical concerns, not least of which is the question of whether or not it is ethically permissible to perform elective surgery to remove a functioning, healthy limb so that it can be replaced with a superior bionic analogue.

Implants are most often discussed in connection with the brain, especially as a means of facilitating mind-machine interfaces (MMI), but given our relatively limited knowledge of the intricacies of the brain, it will come as no surprise that our implant technology is relatively

⁴⁹ Sarah C. P. Williams, “Wax-Filled Nanotubes Flex Their Muscles,” *ScienceNOW* (blog), *Science*, November 15, 2012, <http://news.sciencemag.org/sciencenow/2012/11/wax-filled-nanotubes-flex-their-.html> (accessed November 25, 2012); Márcio D. Lima et al., “Electrically, Chemically, and Photonically Powered Torsional and Tensile Actuation of Hybrid Carbon Nanotube Yarn Muscles,” *Science* 338 (2012): 928–932, doi:10.1126/science.1226762 (accessed November 25, 2012).

limited at this time. Perhaps the most successful and widespread example is that of the cochlear implant for individuals who are profoundly deaf or have severe hearing loss. However, scientists have been making strides towards more sophisticated implementations of implant technology in parts of the body that are less durable and more susceptible to damage. Miika Terho, a Finnish man, lost his sight due to a condition called retinitis pigmentosa, a degenerative eye disease that progressively limits the amount of visual information that is sent to the optic nerve. In November 2008, researchers surgically implanted a microchip with specialized probes behind the retina of one of his eyes, where it could effectively bridge the missing connections between the eye's photoreceptors and the optic nerve; the implant allowed him to make out rudimentary shapes in black and white for the first time since losing his vision.⁵⁰ Similar implants, also created for individuals suffering from retinitis pigmentosa, have been designed to perform on-the-fly translations of printed material into visual representations of Braille, allowing the user to more quickly make out letters and words where conventional Braille notations are unavailable, as in public areas.⁵¹ Scientists have also achieved promising results with artificial retinas made of silicon that not only relay signals directly to the optic nerve, but—by mimicking “the retina’s

⁵⁰ Rob Spence, “Deus Ex – The Eyeborg Documentary,” Square Enix, YouTube video, 1:32, <http://www.youtube.com/watch?v=TW78wbN-WuU> (accessed August 25, 2011).

⁵¹ Douglas Heaven, “Implant lets the blind read Braille with their eyes,” *New Scientist*, November 22, 2012, <http://www.newscientist.com/article/dn22525-implant-lets-the-blind-read-braille-with-their-eyes.html> (accessed November 25, 2012); Nidhi Subbaraman, “Bionic Eye Lets a Blind Person ‘See’ Braille,” *MIT Technology Review*, <http://www.technologyreview.com/view/507796/bionic-eye-lets-a-blind-person-see-braille> (accessed November 25, 2012); Thomas Z. Lauritzen, “Reading visual braille with a retinal prosthesis,” *Frontiers in Neuroscience* 6 (November 2012): 168, doi:10.3389/fnins.2012.00168 (accessed November 25, 2012).

neuronal specializations, synaptic configuration, and functional architecture”—do so with computational speed and energy efficiency approaching that of their biological counterparts.⁵²

Despite the challenges facing those seeking rich, seamless MMIs at this point, a number of experimental programs give indications that such visions are not as far off as some would have it. As was mentioned previously, researchers’ work on artificial neural networks has yielded some insights into the architecture of the basic unit of the neural net: the neuron. Thanks to improved imaging techniques, scientists are developing an ever-more-detailed picture of the intricate system of connections between neurons, or “neuronal ‘wiring diagrams’,” as one research team calls them.⁵³ This, in turn, has helped advance efforts to develop more sophisticated emulations of neuronal activity, including “complex neuronal ion channel and intracellular ionic dynamics” thought to drive learning and memory formation in mammalian brains, on relatively commonplace CMOS microchips.⁵⁴ Recent tests in rhesus monkeys with a neural implant surgically inserted into their prefrontal cortices showed marked improvements in their artificially diminished decision-making abilities, suggesting that such implants could potentially augment brain function in otherwise healthy humans.⁵⁵ In the future, similar neural implant technology might even be able to circumvent or even repair severe brain trauma in patients in a persistent vegetative state, who, recent research has suggested, may in fact be capable of communicating via

⁵² Kareem A. Zaghloul and Kwabena Boahen, “A silicon retina that reproduces signals in the optic nerve,” *Journal of Neural Engineering* 3 (2006): 257-267, doi:10.1088/1741-2560/3/4/002 (accessed November 9, 2012).

⁵³ Kevin L. Briggman and Davi D. Bock, “Volume electron microscopy for neuronal circuit reconstruction,” *Current Opinion in Neurobiology* 22 (2012): 154-161, doi:10.1016/j.conb.2011.10.022 (accessed July 14, 2012).

⁵⁴ Guy Rachmuth et al., “A biophysically-based neuromorphic model of spike rate- and timing-dependent plasticity,” *Proceedings of the National Academy of Sciences*, published electronically on November 16, 2011, doi:10.1073/pnas.1106161108 (accessed November 16, 2011).

⁵⁵ Robert E. Hampson et al., “Facilitation and restoration of cognitive function in primate prefrontal cortex by a neuroprosthesis that utilizes minicolumn-specific neural firing,” *Journal of Neural Engineering* 9 (2012): 1-17, doi:10.1088/1741-2560/9/5/056012 (accessed November 15, 2012).

functional MRI (fMRI).⁵⁶ Researchers at MIT recently announced the development of a glucose-based fuel cell that can be implanted in one of the cavity spaces surrounding the brain and generate up to 180 μW of (peak) energy from the circulating cerebrospinal fluid, which possesses a high glucose content, specifically to power MMIs.⁵⁷ (In its current iteration, the fuel cell actually produces enough steady-state power to meet the estimated energy requirements of Babak Parviz's bionic contact lenses.) Farther into the future, these insights could be used to achieve whole brain emulation, "[t]he basic idea" of which "is to take a particular brain, scan its structure in detail, and construct a software model of it that is so faithful to the original that, when run on appropriate hardware, it will behave in essentially the same way as the original brain."⁵⁸ Of course, should MMIs and other neural implants with some form of wireless connectivity become prevalent, serious consideration will need to be given over to neurosecurity.⁵⁹ (This would also extend to potential cognitive "backups" of one's own mind, for obvious reasons.) But with the progress being made today, it is not inconceivable that we will be able to interact more rapidly, more efficiently, and ultimately more meaningfully with our technology via MMIs—to the point where we might use our minds to communicate with the machinery that will ensure that our minds will live on past the death of the body.

⁵⁶ David Cyranoski, "The Mind Reader," *Nature* 486 (June 14, 2012): 178-180, http://www.nature.com/polopoly_fs/1.108161/menu/main/topColumns/topLeftColumn/pdf/486178a.pdf (accessed November 22, 2012).

⁵⁷ Benjamin I. Rapoport, Jakub T. Kedzierski, and Rahul Sarpeshkar, "A Glucose Fuel Cell for Implantable Brain-Machine Interfaces," *Public Library of Science* 7, no. 6 (June 2012): 1-15, doi:10.1371/journal.pone.0038436 (accessed November 3, 2012).

⁵⁸ Anders Sandberg and Nick Bostrom, *Whole Brain Emulation: A Roadmap*, Technical Report #2008-3, Future of Humanity Institute, Oxford University, <http://www.fhi.ox.ac.uk/reports/2008-3.pdf> (accessed August 16, 2012); Kenneth J. Hayworth, "Electron Imaging Technology for Whole Brain Neural Circuit Mapping," *International Journal of Machine Consciousness* 4, no. 1 (2012): 1-22, doi:10.1142/S1793843012500060 (accessed July 14, 2012).

⁵⁹ Ariel Garten, "Securing Our Minds: The Need for Brainwave Tech Standards Against Hacking," *TechCrunch* (blog), September 15, 2012, <http://techcrunch.com/2012/09/15/securing-our-minds-the-need-for-brainwave-tech-standards-against-hacking> (accessed September 16, 2012).

CHAPTER 5 – REGULATING AN UNFORESEEN FUTURE

Throughout history, technological development has almost invariably spurred enormous social, economic, and political change. The development of division of labor during the Agricultural Revolution gave rise to the underlying principles of civilization; the emergence of written language fundamentally changed the means by which human beings communicated with one another, and enabled the basic forms of the more complex systems of civilization to arise. Metalworking broadened the range of man's implements, and therefore his capabilities. The advent of deepwater shipbuilding began to "shrink" the world for the very first time, while gunpowder toppled the stagnant edifice of medieval Europe. The printing press revolutionized the dissemination of information, and the Industrial Revolution cemented the dominance of the urban social paradigm over its rural counterpart. The automobile and the airplane created the suburbs and forever altered the dynamics of travel and commerce, and the list of things that the Internet has *not* changed only grows smaller with every passing day.

Of course, many of these major leaps have brought with them attendant calamities. Although technology is itself amoral, the ends for which they are used clearly obtain moral value. One could argue, however, that the nature of a newly-developed technology can circumscribe the range of likely moral outcomes from its use. For example, nuclear technology effectively entered the world under the auspices of the Manhattan Project, and while prototype nuclear reactors had already been created as part of that effort, the first commercial nuclear power plant would not open until 1956; as such, it would not be entirely unreasonable to suggest that any use of viable

nuclear technology during its first decade of existence would have very likely not been peaceful.¹ The very first such use was, of course, unequivocally *not* peaceful, and the disasters at Chernobyl and more recently Fukushima are stark examples of the tragedies that can result even from peaceful uses of technology. Unsurprisingly, existential anxieties over the idea that we might destroy ourselves with our own technology have run high since the end of World War II and the beginning of the Cold War. Although the spectre of mutually assured destruction essentially died with the Soviet Union, technological innovation has also inadvertently increased the amount of potential destructive power that an individual can wield—the potential use of bioweapons, or even a well-placed computer virus in the control systems of critical infrastructure (as in the use of the Stuxnet virus against Iranian nuclear enrichment facilities), could inflict unthinkable amounts of destruction on a national or even global scale.

THE SHORT TRUDGE FROM ADAM TO ATOM

Naturally, these grim scenarios do not constitute the only basis for regulation of technology; regulation is also commonly employed to promote positive socioeconomic outcomes, as well as mitigating potentially negative effects that may arise in the course of technological or socioeconomic developments (e.g., polarizing degrees of social stratification, decreased social mobility, discrimination, etc.). With few exceptions, there exists broad political support for the notion that some basic level of regulation is necessary to enable the quality of life

¹ *The Engineer*, “Calder Hall Nuclear Station,” October 5, 1956, <http://www.theengineer.co.uk/journals/pdf/21835.pdf> (accessed November 17, 2012).

to which we are generally accustomed.² The elixir sulfanilamide tragedy of 1937, for example, demonstrated the need for a unified regulatory body that could establish authoritative standards for food and drug products, and enforce them if needed; this idea was essentially validated by the vigilance and perseverance of Frances Oldham Kelsey at the FDA during the thalidomide crisis in the early sixties. However, at the same time, regulations must be carefully crafted so as to avoid having a disproportionately negative impact, relative to their purported benefits, on industry or the public. While this is easily said, it is not always easily done. In contrast to its unequivocally beneficial work in such areas as managing national spectrum resources and promoting net neutrality, the FCC's use of vague and subjective "community standards" to regulate obscene broadcast content has resisted numerous attempts by both Congress and the Supreme Court to establish clear and equitable criteria for said standards. This has been true to the point where Justice Potter Stewart's 1964 remark in reference to defining hardcore pornography, "I know it when I see it," has become an iconic part of the Court's history.³ Furthermore, regulations must either contain in their initial form, or allow for the subsequent introduction of, some measure of flexibility to ensure its continuing applicability through years and years of socioeconomic, political, and technological change. As was detailed in Chapter 3, the Court's refusal to address the wildly outdated standard by which they justified controls on televised speech in 1978's *FCC v.*

² Although anarchists, strict minarchists, and others of similar political convictions would undoubtedly contest this assertion, virtually all other extant political systems accept the idea that individuals' freedom must be curtailed to at least some degree in order to make possible the formation of a stable society—and, furthermore, that abiding by these agreed-upon limitations participation is a condition of membership in such a society.

³ *Jacobellis v. Ohio*, 378 U.S. 184 (1964), 197, <http://supreme.justia.com/cases/federal/us/378/184/case.html> (accessed November 18, 2012). In fairness, Stewart later expressed regret over his authorship of that particular phrase, despite it having been widely held up as evidence of his "pragmatism and moderation" in judicial matters. Al Kamen, "Retired High Court Justice Potter Stewart Dies at 70," *Washington Post*, December 8, 1985, http://www.washingtonpost.com/local/obituaries/retired-high-court-justice-potter-stewart-dies-at-70/2011/12/03/gIQA9mhjPO_story.html (accessed November 18, 2012).

Pacifica Foundation has led to a highly subjective and inconsistent censorship regime in the form of the FCC—a system which remains in place at the FCC despite numerous technological developments to give parents finer-grained controls over the televised content they allow into their homes, in stark contrast to the Court’s historical commitment to the parental liberty doctrine.⁴

It can hardly be disputed that these notions, writ large, continue to obtain today. Since even the beginning of the twentieth century, no one person could be reasonably expected to be knowledgeable about any significant fraction of the myriad complexities of modern life—let alone all of them—and so the need became apparent for regulatory agencies to address those societal phenomena which were, fundamentally, manifestations of the growing information gap between the specialist and the average citizen. As the rate of technological progress has dramatically increased up to the present, so too has this information gap. Consequently, the need for the redressing function of regulatory bodies is all the more vital today—for if a matter as basic as maintaining the purity of our food and drug products is deemed worthy of regulatory oversight, one could hardly argue for anything less in the face of technologies that stand to irrevocably and fundamentally alter our understanding of human nature. Although it cannot be denied that these technologies have the potential to confer unparalleled benefits upon us, this by no means excuses

⁴ “If parents choose not to use the many available tools for controlling media in their house, the FCC cannot constitutionally claim that this gives them the right to act *in loco parentis*. That conclusion follows from this Court’s holding that governmental action to promote parents’ voluntary efforts to protect their children from sexual content is a less restrictive alternative to statutorily mandated blocking.” Brief of the Cato Institute et al. as Amici Curiae in Support of the Respondents, *FCC v. Television Stations, Inc.*, 567 U.S. ____ (2012), 21, <https://www.efc.org/sites/default/files/FCC%20v.%20Fox%20amicus.pdf> (accessed Nov. 30, 2011).

a *laissez-faire* attitude towards their anticipated arrival, for they could also potentially exacerbate existing problems.

This includes such thorny issues as the fundamental inequalities between the so-called “haves” and “have-nots” of society. Even today, democratic societies around the world continue to grapple with the difficulties posed by the outsized political influence of the wealthy; as one might imagine, such difficulties would be cast in even sharper relief if the wealth of the upper class—and only that kind of wealth—could buy them bionic augmentations and nanotechnological enhancements that could effectively endow them with superhuman abilities and eternal youth. Less extreme examples of this divide in access to enhancement technologies are hardly better: even if such technologies developed to a degree that they were more broadly affordable by members of the middle class, the lower class and the poor could still find themselves in a dystopian world where those without the enhanced intelligence, strength, and health of the bionically- and nanotechnologically-augmented are shut out from the larger economy—which would have reoriented itself towards the augmented—and thus condemned to a life of perpetual poverty. To say that the ethical and social implications of such a scenario are profoundly disturbing would be an understatement. These possibilities are admittedly among the most dire on the metaphorical spectrum, but to assume the implausibility of their happening as a result would be a mistake; rather, the fact that such nightmarish futures *could* come to pass only

underscores the need to establish basic regulatory frameworks for emerging technologies *before* they hit the market.⁵

A closer look at the potential effects of the predicted applications of the emerging technologies examined in the previous chapter reveals the inadequacies of our current regulatory systems. The basic foundations of government are likely to be particularly vulnerable, based as they are (for obvious reasons) on the extant range of human capabilities, and as mired in organizational inertia as they are. Although examples of effective regulatory responses at the federal level to emerging technologies do exist, the overall trend is less than encouraging. For example, while the FDA Modernization Act of 1997 was hailed for effectively preparing the FDA to regulate products beginning to appear from the then-emerging field of biotechnology, the House Judiciary Committee’s markup session on SOPA in December 2011 highlighted a troubling lack of technical knowledge in many of the representatives tasked with deciding on a floor vote for a bill that would have had sweeping effects on websites, online services, and ordinary users across the world.⁶ Indeed, the tenor of those proceedings, dominated by the

⁵ Enita A. Williams, *Good, Better, Best: The Human Quest for Enhancement*, ed. Mark S. Frankel, report from the Scientific Freedom, Responsibility and Law Program of the American Association for the Advancement of Science, June 1-2, 2006, http://www.aaas.org/spp/sfrl/projects/human_enhancement/pdfs/HESummaryReport.pdf (accessed October 11, 2011).

⁶ David L. Stepp, “The History of FDA Regulation of Biotechnology in the Twentieth Century” (unpublished third-year paper, Harvard Law School, 1999), 113, http://leda.law.harvard.edu/leda/data/257/Stepp,_David_00.pdf (accessed October 18, 2012). Among the more notable remarks made by members of the Judiciary Committee during the SOPA markup session were: (1) the thematically-emblematic statement by SOPA supporter Rep. Melvin Watt (D, NC-12), “I am not a nerd,” prior to rejecting without explanation the objections of a number of prominent IT experts to the bill in an open letter; (2) the allegation of SOPA advocate Rep. Maxine Waters (D, CA-35) that opponents of the bill—including Reps. Jason Chaffetz (R, UT-03), Darrell Issa (R, CA-49), Zoe Lofgren (D, CA-16), Dan Lungren (R, CA-03), Jared Polis (D, CO-02), and Jim Sensenbrenner (R, WI-05)—were “wasting all of [the committee’s] time” and trying to “obstruct” the bill’s progress by bringing up experts’ cybersecurity-related concerns; and (3) a tweet from Rep. Steve King (R, IA-05), who was absent from the markup session, that he was “so bored” by the ongoing remarks of Rep. Sheila Jackson Lee (D, TX-18) that he had, ironically, resorted to

Committee’s pro-SOPA majority, invited sharp criticism from the media, with journalists lamenting “that Congress doesn’t actually seem to know all that much about the Internet,” that “it isn’t clear whether they even *want* to [learn how the Internet works],” and that it was “head-bangingly frustrating...to see elected officials gleefully admit they don’t understand the technology they’re about to regulate.” One reporter even referred to the sessions as “a horrifying dream” where “a group of well-intentioned middle-aged people who could not distinguish between a domain name and an IP address were trying to regulate the Internet.”⁷

THE MARK OF A GOOD ACTION

Unsurprisingly, what proposals have been made to date regarding the emerging technologies of today have largely come from many of the regulatory agencies that would themselves likely be tasked with regulating the commercial applications of those technologies. But regardless of however valuable these agencies might be in an advisory capacity in the policymaking process, a number of pressing potential issues lie outside their jurisdiction. Ultimately, it will be up to legislators to make decisions on such matters as whether or not to

“killing time by surfing the Internet.” House Committee on the Judiciary, *Markup of H.R. 3261, Stop Online Piracy Act*, 112th Cong., 1st sess., 2011, 182, 211-212, 217, <http://judiciary.house.gov/hearings/pdf/transcript12152011.pdf> (accessed November 18, 2012); Rep. Steve King, Twitter post, December 15, 2011, 9:43 a.m., <https://twitter.com/SteveKingIA/status/147371129177255936> (accessed November 18, 2012).

⁷ T.C. Sottek, “SOPA: the public debate,” *The Verge* (blog), December 23, 2011, <http://www.theverge.com/2011/12/23/2657485/sopa-pipa-debate-boycott-petition-activism-bieber> (accessed November 19, 2012); Joshua Kopstein, “Dear Congress, It’s No Longer OK to Not Know How the Internet Works,” *Motherboard* (blog), *Vice*, December 16, 2011, <http://motherboard.vice.com/2011/12/16/dear-congress-it-s-no-longer-ok-to-not-know-how-the-internet-works> (accessed November 19, 2012); Mike Masnick, “Dear Congress, It’s No Longer OK to Not Know How the Internet Works,” *TechDirt* (blog), December 16, 2011, <http://www.techdirt.com/articles/20111216/12082717110/dear-congress-its-no-longer-ok-to-not-know-how-internet-works.shtml> (accessed November 19, 2012); Alexandra Petri, “The nightmarish SOPA hearings,” *ComPost* (blog), *Washington Post*, December 15, 2011, http://www.washingtonpost.com/blogs/compost/post/the-nightmarish-sopa-hearings/2011/12/15/gIQA47RUwO_blog.html (accessed November 19, 2012).

acknowledge a legal distinction between bionic and/or nanotechnological augmentations used for curative or enhancement purposes, and thus whether or not (and under what circumstances) they should be classified as elective procedures or procedures that would be covered by health insurance; whether the free market alone should dictate the rationing of these technologies, or whether the government should subsidize them, or even institute public programs to allocate some quantity of them to individuals who would otherwise be passed over by market forces; what modifications may need to be made to our “social safety net” in a time when large numbers of citizens could potentially have centuries of good health rather than decades; and how our economic system and activities would need to change in order to accommodate the vast drop in mortality that would accompany such a dramatic extension of the average lifespan.⁸ Furthermore, tackling these economic issues, already a monumental task in and of itself, will also require a deft touch with regards to the inevitable—and potentially enormous—sociopolitical consequences.⁹

⁸ Williams, *Good, Better, Best*. Although some of the more optimistic futurist thinkers have suggested that attaining such an advanced level of nanoscale manipulation would effectively pave the way for a so-called *post-scarcity* society—in which the economic concept of scarcity, regulated today in the form of money, is effectively made obsolete—through such new paradigms as “molecular manufacturing,” the post-scarcity concept is not without its critics, and for obvious reasons should not be relied upon as an preordained panacea. Izabella Kaminska, “The end of artificial scarcity,” *FT Alphaville* (blog), *Financial Times*, June 8, 2012, <http://ftalphaville.ft.com/2012/06/08/1030801/the-end-of-artificial-scarcity> (accessed November 19, 2012); Eric Drexler, “Molecular manufacturing will use nanomachines to build large products with atomic precision,” May 13, 2004, <http://e-drexler.com/p/04/03/0325molManufDef.html> (accessed November 19, 2012). See also Izabella Kaminska, “Redefining labour,” *FT Alphaville* (blog), *Financial Times*, June 12, 2012, <http://ftalphaville.ft.com/2012/06/12/1037001/redefining-labour> (accessed November 19, 2012); Eric Drexler, “Engines of Abundance,” in *Engines of Creation: The Coming Era of Nanotechnology* (New York: Anchor Books, 1986), http://e-drexler.com/d/06/00/EOC/EOC_Chapter_4.html (accessed November 19, 2012); Eric Drexler, *Engines of Creation 2.0: The Coming Era of Nanotechnology* (published by author, 2006), PDF e-book, http://www1.appstate.edu/dept/physics/nanotech/EnginesofCreation2_8803267.pdf (accessed November 19, 2012).

⁹ Williams, *Good, Better, Best*, 5. Williams’ analysis, written in 2006, appears not to lend much weight to concerns over intergenerational conflict, seemingly endorsing the view mentioned therein that “the idea...was constructed in the press...[with] supporters citing anecdotal, but little scientific evidence.” Six years later, in the wake of the 2008 financial crisis, continuing economic uncertainties—including the highest recorded levels of youth unemployment in U.S. history—have given rise to such phenomena as the Occupy Wall Street movement and similarly youth-driven demonstrations and protests around the world, lending somewhat more credence to the idea that the future may

It is promising, then, that what work is being done along these lines is largely dedicated to not only exploring the plausible and likely uses of these technologies as they mature, but also to best mitigate or avoid any unintended consequences that may come from their use. Nanotechnology has been feted as the solution to a number of the most pressing issues we face today, including global warming and attendant environmental degradation, reducing agricultural and industrial waste, enabling sustainable development by reducing the ecological impact of our technology. Organizations like the National Science Foundation (NSF) and the Environmental Protection Agency (EPA) have already crafted substantive proposals outlining potential uses for nanotechnology in these areas and more, as well as potential areas of concern: nanotechnology could provide farmers with molecular-level data about livestock health and soil integrity to improve and more accurately project seasonal yields; make use of molecular manufacturing to construct needed materials out of “common chemical elements” instead of “rare metals or nonrenewable energy supplies”; create adaptive construction materials so buildings “could automatically change shape and color to adjust to different conditions of temperature, lighting, wind, and precipitation”; remove contaminants from polluted areas; efficiently desalinate and purify water; improve energy efficiency and potentially catalyze the “hydrogen economy”; and reduce the use of toxic and corrosive pollutants in manufacturing. At the same time, the EPA has made clear the need to obtain more concrete information on the complex and idiosyncratic

hold punishing political conflicts over such issues as social benefits for the elderly and intergenerational differences in wealth distribution and tax burden. Stephen Marche, “The War Against Youth,” *Esquire*, April 2012, <http://www.esquire.com/features/young-people-in-the-recession-0412> (accessed November 25, 2012); Jim Tankersley, “Who Destroyed the Economy? The Case Against the Baby Boomers,” *The Atlantic*, October 5, 2012, <http://www.theatlantic.com/business/archive/2012/10/who-destroyed-the-economy-the-case-against-the-baby-boomers/263291> (accessed October 5, 2012); “Generational warfare: Occupy grandma’s house,” *Free exchange* (blog), *The Economist*, October 5, 2011, <http://www.economist.com/node/21534305> (accessed August 29, 2012).

physical and chemical properties of nanomaterials, their biodegradability and bioaccumulation properties in a variety of environmental media, their potential effects on human health, and how to effectively detect and respond to unintentional and potentially harmful exposures to nanomaterials.¹⁰ Other organizations, like the American Association for the Advancement of Science (AAAS), meanwhile, are also giving over thought to potential risks, such as the weaponization of nanotechnology to “de-enhance” enemy combatants in a lethal reverse-engineering of augmentation and enhancement technologies, or the creation of new and even deadlier forms of nuclear, biological, chemical, or explosive weapons, and how to adapt current arms control schema to address such scenarios.¹¹

Human enhancement technologies themselves will also require significant changes to our regulatory paradigms. On the most basic level, HETs will force us to rethink many of our assumptions about our relationship to the physical world around us—our architecture, defenses, and weaponry are just a few of the many things that are essentially premised on “average” human abilities. What good is an eight-foot-high wall around a secure structure, for example, if a person

¹⁰ Mihail C. Roco and William Sims Bainbridge, eds., *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, prepared by the National Science Foundation in cooperation with the U.S. Department of Commerce (Arlington, VA, 2002): 20-21, 79-96, <http://www.nanowerk.com/nanotechnology/reports/reportpdf/report87.pdf> (accessed November 18, 2011); U.S. Environmental Protection Agency, *Nanotechnology White Paper*, prepared for the EPA by the Nanotechnology Workgroup of the EPA Science Policy Council (Arlington, VA, 2007), <http://www.epa.gov/osa/pdfs/nanotech/cpa-nanotechnology-whitepaper-0207.pdf> (accessed September 2, 2012). See also J. Clarence Davies, *Nanotechnology Oversight: An Agenda for the New Administration*, prepared by the Project on Emerging Nanotechnologies from the Woodrow Wilson International Center for Scholars in cooperation with the Pew Charitable Trusts, July 2008, <http://www.nanotechproject.org/process/assets/files/6709/pen13.pdf> (accessed October 13, 2011).

¹¹ Williams, *Good, Better, Best*, 9; Jürgen Altmann, *Military Nanotechnology: Potential applications and preventative arms control* (London: Routledge, 2006), 81-82, 98-104, http://cs5292.userapi.com/uf1728334/docs/6695f813f83d/Jurgen_Altmann_Military_Nanotechnology_Potent.pdf (accessed November 19, 2012). See also Daniel McIntosh, “The Transhuman Security Dilemma,” *Journal of Evolution and Technology* 21, no. 2 (December 2010): 32-48, <http://jetpress.org/v21/mcintosh.htm> (accessed November 13, 2011).

augmented with bionic limbs can easily jump eight feet or more into the air? Similarly, what good would bullets be against such an augmented intruder if he could avoid them with superhuman reflexes and speed, or even shrug them off with dermal armor implants? New security standards and protocols would need to be implemented in both government and the private sector to account for the exceptional capabilities of augmented malcontents; law enforcement could conceivably face the spectre of either unaugmented officers attempting to apprehend augmented suspects, or augmented officers potentially causing serious or even fatal injuries to unaugmented citizens. Furthermore, institutions across all branches of government will have to address the ethical, socioeconomic, and political ramifications of limited access to HETs. There exist “profound social risks” to the proliferation of HETs, not least of which is their “potential to undermine the shared human nature that sustains human society”; our social institutions have already been “greatly challenged” by the rapid pace of technological development, and “our ontologies and cultural constructs,” as well as our language, are “flagging in the race to keep pace with HE technologies.” And yet, we citizens of an advanced democratic society are faced with the necessary task of establishing “a socially acceptable criterion for determining who deserves priority access to [HETs]” in the face of inevitable economic scarcity. New battle lines will be drawn along lines of so-called “bio-politics,” which will come to act as the political manifestations of differing views on the morality of HETs, and which could raise political polarization to unparalleled heights. Still, within a “strong precautionary framework” that promotes “an individual’s right to express personhood, excel, and reach his/her fullest potential,” and concentration on the age-old ills of “greed, racism, inequality, and ignorance”

which might manifest themselves in the discourse surrounding HETs as the key issues, rather than HETs themselves, such issues might be effectively mitigated or even averted.¹²

Augmented reality, while perhaps of less existential import than the myriad applications of nanotechnology and human enhancement technologies, still faces regulatory hurdles of its own. In order for the vision of persistent augmented reality as presented in the previous chapter to come to pass, several major regulatory agencies covering a variety of industries and fields will need to collaborate and approve the technologies required to bring it to fruition. Among these are the FCC, which will need to continue to assess and allocate national spectrum resources to enable the continuing operation of the millions of wireless devices in use across the nation, as well as expanding Internet connectivity to unserved areas and improving connection speed and bandwidth in populated areas; the FDA, which will necessarily have to assess the safety of products like the bionic contact lens; and the Federal Trade Commission (FTC), which may need to monitor for and regulate potential advertising schemes that might unduly infringe on one's augmented vision, which could be dangerous, as well as continuing to promote consumers' interests by advocating for data privacy rights. The combination of pervasive networking, ubiquitous wireless, and persistent augmented reality also stands to further the present shift in social norms between social sharing and privacy; this will in turn involve such groups as legislators and lawyers to revise laws to reflect this new reality, law enforcement to identify and pursue criminal activities relating to these new forms of interaction, and information technology and networking experts to create new protocols for applications of augmented reality and harden

¹² Williams, *Good, Better, Best*; Institute for Ethics and Emerging Technologies, "Overview of Biopolitics," <http://ieet.org/index.php/IEET/biopolitics> (accessed November 13, 2011).

existing protocols to better protect individuals' privacy and data.¹³ In the same vein, the electorate will most likely have to make an active decision on the government's surveillance powers, including warrantless wiretaps across a variety of telecommunications devices, in the years to come, as the problem of violations of individuals' personal and data privacy by law enforcement officials will only grow more acute as more and more aspects of our lives become digitized.

The emerging technologies of today, with their enormous range of potential applications, offer us the opportunity to live longer and healthier lives, dramatically improve our mental and physical capabilities, repair the ecological damage we have inflicted on our planet, and understand and shape nature itself at its most fundamental levels. For every technology that has been covered here, there are many more which have not been mentioned—and this vast range of technologies is only outstripped by the wealth of possibilities they could collectively unlock for us. Although the task of effectively preparing for the advent of these technologies might seem insurmountably difficult—particularly in a time of gridlocked, polarized politics, and apparent legislative disregard for technical details—one need only revisit the recent past to be reminded that our prudence towards and knowledge of the ramifications of new technologies have tended to trend upwards alongside the progress of our technology itself. At the same time, it must not be

¹³ Robert N. Charette, "Is It Time for a Computer Industry Do-Over?", *The Risk Factor* (blog), *IEEE Spectrum*, October 30, 2012, <http://spectrum.ieee.org/riskfactor/computing/it/is-it-time-for-the-computerindustry-to-take-a-mulligan> (accessed November 15, 2012). For a thought-provoking future depiction of how persistent AR might shift our social norms and interactions—and potentially introduce new and difficult ethical issues in the process—see Eran May-Raz and Daniel Lazo, "Sight," short film, July 24, 2012, <http://vimeo.com/46304267> (accessed July 29, 2012); for a contemporary take on how the technology is currently developing and how it might be used in the interim, see Alexis Madrigal, "The World Is Not Enough: Google and the Future of Augmented Reality," *The Atlantic*, October 25, 2012, <http://www.theatlantic.com/technology/archive/2012/10/the-world-is-not-enough-google-and-the-future-of-augmented-reality/264059> (accessed October 25, 2012).

forgotten that the vagaries of human nature have also led to the application of our technology in truly atrocious ways, and for the most hideous of ends. And yet, the fact that our species managed to avoid nuclear self-destruction during the twentieth century is surely an encouraging sign for our prospects for the future. Although this paper has gone to considerable lengths to demonstrate the rapidity of technological innovation occurring even now, we should not—indeed, *cannot*—mistake speed for ease; likewise, the reasoning heretofore provided for the likelihood of the near-future emergence of the technologies mentioned herein is by no means a guarantee of success. But with the provision of even modest resources towards the continuing study of these emerging technologies and others, unremitting vigilance against the emergence of new potential risks, public-private dialogue between regulatory agencies and corporations engaged in the development of emerging technologies, and the early establishment of flexible precautionary regulatory frameworks with expert input, many of us alive today might yet see the human race flourish as never before. We need only to remember our common heritage and nature to spur on that instinctual sense of responsibility we possess which will, in due course, be necessary to reap the ultimate rewards of our ancestors' aeonic toil.

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